EFFECTS OF THE ACTION

Effects Common to All Species

Interrelated and interdependent actions

An "interrelated activity" is an activity that is part of the proposed action and depends on the proposed action for its justification. An "interdependent activity" is an activity that has no independent utility apart from the proposed action. Regulations implementing section 7(a)(2) of the Act require the Services to consider the effects of activities that are interrelated or interdependent with the proposed Federal action (50 CFR §402.02).

There are no known interrelated or interdependent activities that have effects common to all of the species proposed for coverage under the ITPs. Those interrelated and interdependent activities with effects common to specific groups of species, i.e., salmonids and amphibians and aquatic reptiles, are discussed in the specific sections relating to those species.

Effects Common to Species Associated with Late-Seral Habitat

Direct effects

Species

Injury or disturbance

Late-seral associated species may be disturbed by covered activities around nest or den sites. The use of motorized equipment, helicopters, or blasting during the breeding season in or near late-seral habitat has the potential to disrupt essential foraging or breeding behaviors by: 1) causing abandonment of the breeding effort by failure to initiate courtship or nesting and denning, or complete incubation, 2) disrupting nesting/denning activity such as feeding young, and 3) causing premature fledging or dispersal of juveniles. A lack of breeding effort or breeding activity would negatively affect annual reproduction. Premature fledging or dispersal of juveniles may result in the increased likelihood of death or injury due to predation, lack of sheltering, or injury. Disturbance avoidance measures contained in the HCP will minimize these effects for most of the covered species.

Suitable habitat

Habitat protection

Over the life of the SYP/HCP, certain areas (MMCAs and RMZs) which contain LSH will be subject to little or no timber management activity. These areas are likely to provide the highest density of structural components important to late-seral associated species, thus providing the highest quality habitat over the permit period for these species. The acres protected within no harvest buffers of RMZs can vary post-watershed analysis. The post-watershed analysis width of the protection buffers can vary from 170 to 30 feet for Class I, from 170 to 10 feet for Class II, and from 30 to 0 feet for Class III RMZs. The no harvest buffer on Class II RMZs could only be reduced to 10 feet if the wildlife agencies determine that such reduced buffers would benefit aquatic species. Table 34 provides acres of LSH on PALCO lands in areas restricted from timber harvest activity by decade, using a "worst case" estimate for protection within RMZs. The Services believe that reduction of Class II RMZ no harvest buffers below 30 feet is unlikely. Therefore, our "worst case" analysis will analyze Class II RMZ no harvest buffers of 30 feet.

Table 34. A "worst case" estimate on the amount of LSH protected from timber harvest in RMZs applying the minimum no harvest buffer widths that could result post-watershed analysis (30 feet on Class I and Class II RMZs), as well as other areas protected from harvest on PALCO lands.

Decade	[1]MMCAs	[2]Grizzly Creek Complex	[3]Class I and II RMZs	Total Acres
Present	4,815	973	2,602	8,390
Decade 1	4,815	0	2,676	7,491
Decade 2	4,815	0	3,029	7,844
Decade 3	4,815	0	3,098	7,913
Decade 4	4,815	0	3,560	8,375
Decade 5	4,815	0	3,695	8,510

[1] For the purpose of this analysis we assumed that the acres of LSH would remain constant over the permit term, although acres of LSH are likely to increase as the mid-seral forests within the MMCAs grow. Data was not available to estimate the amount of ingrowth of LSH over the period.

[2] For the purpose of analyzing impacts to terrestrial covered species, other than the marbled murrelet, it is assumed that the Grizzly Creek Complex will only be protected from harvest for 5 years.

[3] The minimum no harvest buffer for Class III RMZs is 0 feet, therefore Class III RMZs are not included in these figures.

Since acres protected within RMZs can vary post-watershed analysis, we have also included an estimate of the maximum amount of LSH that would be protected from timber harvest post watershed analysis. Table 35 provides a "best case" estimate of acres of LSH on PALCO lands restricted from timber harvest within Class I and II RMZs.

Table 35. The "best case" estimate, using LTSY projections, of the amount of LSH protected from timber harvest in Class I and II RMZs on PALCO lands applying the maximum no harvest buffer widths (170 feet) that could result post-watershed analysis.

RMZ	Present	Decade 1	Decade 2	Decade 3	Decade 4	Decade 5
Class I	4,265	4,011	4,440	4,466	4,918	5,409
Class II	11,649	10,387	11,314	11,285	13,153	15,895
Total	15,914	14,398	15,754	15,751	18,071	21,304

The initial watershed analyses must be completed within five years of ITP issuance. The post-watershed analysis harvest prescriptions for RMZs will vary across the ownership by hydrologic unit, and prescriptions will be revisited every five years, or sooner due to changed circumstances. Thus, we cannot predict the acres of LSH protected within RMZs over the permit period. The acres protected will fall between the "best case" and "worst case" estimates described above.

In addition to PALCO lands, the Headwaters acquisition area is within the action area and contains 5,304 acres of LSH. These acres are expected to be present throughout the permit period and beyond.

Habitat modification

Under the SYP/HCP, LSH outside of MMCAs and no harvest buffers in RMZs will be available for harvest during the permit period. In areas subject to timber harvest, the effects of harvest on LSH are dependent upon the silvicultural prescriptions used, and to a lesser degree, the condition of the habitat prior to harvest. As described in the SYP/HCP, the late-seral selection and the selection harvest regimes are designed to maintain late-seral forest conditions. During the permit period, the late-seral selection harvest regime will be applied to approximately 30,786 acres (20 percent) and the selection regime to approximately 2,958 acres (2 percent) (Appendix Q, Final EIS/EIR) of the 154,868 harvested acres. Not all of these acres are currently LSH. The MMCAs, RMZs, and areas managed to address mass wasting and sedimentation concerns will be treated with these prescriptions.

Habitat removal

At a minimum, conservation measures for habitat diversity will retain at least 10 percent of the PALCO ownership in each WAA in LSH throughout the permit period. Using LTSY modeling information, Table 36 projects the amount of late-seral habitat that will be present on PALCO lands by decade. At the end of the first decade, the current amount of LSH will be reduced by 38 percent. By the end of the second decade, the amount of LSH will be reduced by 54 percent. The smallest amount of LSH (42 percent of the baseline acres) will be present by the end of the third decade. LSH is projected to increase in the fourth and fifth decades of the permit period to 47 percent and 58 percent of the baseline acres, respectively, due to ingrowth of habitat.

Table 36. Projected acres of uncut old-growth, residual old-growth, and other LSH on PALCO lands by decade using LTSY model information.

Seral Type	Present	Decade 1	Decade 2	Decade 3	Decade 4	Decade 5
Uncut Old-Growth	6,569	3,940	3,324	3,203	2,467	1,806
Residual Old-growth	18,205	7,875	7,301	6,727	6,605	6,491
Other LSH	44,457	30,042	20,392	19,370	23,033	31,643
Total	69,231	41,857	31,017	29,300	32,105	39,940

Forested areas outside of the MMCAs, RMZs, and areas managed to address mass wasting and sedimentation concerns are not expected to be managed to support late-seral associated species unless additional measures are identified through the adaptive management process outlined in the SYP/HCP. The loss of late-seral habitat will result when the even-aged and shelterwood/seed tree harvest regimes are applied. During the permit period, these harvest regimes will be applied to approximately 106,220 acres (69 percent) of the 154,868 harvested acres.

The use of mechanical equipment in management of forests increases the risk of wildfire. The SYP/HCP identifies responses to changed circumstances including wildfires. If a fire greater than 20 percent of a planning watershed occurs that is less than 5,000 acres in size, an expedited watershed analysis would be completed on the hydrologic unit impacted by the fire. As identified in the watershed analysis process, potential impacts to LSH associated species would be taken into consideration during post-watershed analysis synthesis and prescription development.

Distribution and fragmentation

Fragmentation of LSH will increase over PALCO lands throughout the life of the permit. The number of patches of LSH 475 to 1,000 acres in size, and greater than 1,000 acres in size, will decrease from 13 patches to 9 patches, and from 20 patches to 1 patch, respectively. The number of patches of LSH less than 80 acres in size and 80 to 475 acres in size will increase from 669 patches to 4,588 patches and from 73 patches to 86 patches respectively over the permit period as portions of the larger patches are systematically harvested, creating smaller and smaller intact blocks of LSH. The degree of fragmentation will vary by WAA. PALCO has developed LTSY projections for its ownership. The modeling used for this analysis was conducted on a WAA by WAA basis, therefore habitat patches which overlap between WAAs, are considered two separate patches, dividing at the WAA boundary. Although these projections are not spatially accurate, they do provide general trend information on the degree of fragmentation expected throughout the life of the permit.

Humboldt Bay WAA: The Humboldt Bay WAA totals approximately 128,448 acres, of which PALCO currently owns 38,985 acres (30 percent). At the end of the permit period, the Lower North Fork Elk and Elk Head Residual MMCAs, and other miscellaneous patches, will provide blocks of LSH greater than 80 acres in size. There are currently 18,383 acres of LSH within this WAA. Approximately 6,849 acres of LSH will persist at the end of the permit period, of which, 4,143 acres (60 percent) will be in blocks at least 80 acres in size. Table 37 provides future projections of LSH based on LTSY modeling information.

Table 37. Projected number of patches of LSH and acres of LSH by patch size on PALCO lands in the Humboldt Bay WAA by decade, based on LTSY model information.

Decade	**Patch size**								**Total acres**	**Percent of PALCO lands in WAA**
	0 - 80		**80 - 475**		**475 - 1000**		**>1,000**			
	acres	**no. of patches**	**acres**	**no. of patches**	**acres**	**no. of patches**	**acres**	**no. of patches**		
Present	872	88	1,436	5	679	1	15,415	5	18,402	47
1	1,835	337	1,864	11	2,366	4	2,798	2	8,863	23
2	2,043	479	2,350	14	1,514	2	1,303	1	7,210	18
3	2,139	587	2,180	12	2,129	3	0	0	6,448	17
4	2,209	600	2,436	13	2,064	4	0	0	6,709	17
5	2,706	727	3,042	16	1,101	3	0	0	6,849	18

In addition to PALCO lands, the Headwaters forest acquisition area is within the action area in the Humboldt Bay WAA and is expected to provide LSH throughout the permit period. The Headwaters acquisition area is 7,502 acres in size. It contains approximately 5,304 acres of LSH, of which, 3,783 acres are uncut and residual old-growth habitat. For the purposes of this analysis, the amount of LSH currently existing in the Headwaters acquisition area is assumed to be present throughout the life of the permit.

Yager Creek WAA: The Yager Creek WAA totals approximately 84,541 acres, of which PALCO currently owns 33,730 acres (40 percent). At the end of the permit period, Bell Lawrence, Booth's Run, Road 7 & 9 North, Right Road 9, Shaw Gift, Cooper Mill, Allen Creek and Extension, Road 3, and Owl Creek MMCAs, and other miscellaneous patches will provide blocks of LSH greater than 80 acres in size. There are currently 6,671 acres of LSH within this WAA. Approximately 7,661 acres of LSH will persist at the end of the permit period, of which, 6,347 acres (83 percent) will be in blocks at least 80 acres in size. Table 38 provides future projections of LSH based on LTSY modeling information.

Table 38. Projected number of patches of LSH and acres of LSH by patch size on PALCO lands in the Yager Creek WAA by decade, based on LTSY model information.

Decade	Patch size								Total acres	Percent of PALCO lands in WAA
	0 - 80		80 - 475		475 - 1,000		>1,000			
	acres	no. of patches	acres	no. of patches	acres	no. of patches	acres	no. of patches		
Present	1,064	98	2,065	12	2,198	4	2,102	2	7,429	22
1	802	180	1,056	6	2,679	4	1,118	1	5,655	17
2	764	205	1,024	5	2,620	4	1,267	1	5,675	17
3	786	219	1,029	5	2,622	4	1,159	1	5,596	17
4	1,205	439	727	3	3,650	5	1,241	1	6,823	20
5	1,315	435	782	6	4,291	6	1,273	1	7,661	23

Mad River WAA: The Mad River WAA totals 332,077 acres in size, of which PALCO currently owns 3,904 acres (1 percent). There are currently 158 acres of LSH within this WAA. Approximately 804 acres of LSH will persist at the end of the permit period, of which, 95 acres (0.1 percent) will be in blocks at least 80 acres in size. PALCO's minimal ownership within the Mad River WAA limits the importance PALCO lands play in supporting LSH associated species in the WAA.

Van Duzen River WAA: The Van Duzen River WAA totals 55,361 acres in size, of which PALCO currently owns 24,934 acres (45 percent). At the end of the permit period, a limited amount of LSH would occur in patches greater than 80 acres in size on PALCO lands. There are currently 6,189 acres of LSH within this WAA. Approximately 3,993 acres of LSH will persist at the end of the permit period, of which, 2,228 acres (56 percent) will be in blocks at least 80 acres in size. Table 39 provides future projections of LSH on PALCO lands based on LTSY modeling information.

Table 39. Projected number of patches of LSH and acres of LSH by patch size on PALCO lands in the Van Duzen River WAA by decade, based on LTSY model information.

Decade	Patch size								Total acres	Percent of PALCO lands in WAA
	0 - 80		80 - 475		475 - 1,000		>1,000			
	acres	no. of patches	acres	no. of patches	acres	no. of patches	acres	no. of patches		
Present	1,226	74	2,116	13	1,490	2	1,362	1	6,194	25
1	1,049	149	1,366	8	1,166	2	1,574	1	5,155	21
2	1,320	263	1,406	10	0	0	0	0	2,726	11
3	1,233	278	1,458	9	0	0	0	0	2,691	11
4	1,687	445	2,117	15	0	0	0	0	3,804	15
5	1,765	508	2,228	15	0	0	0	0	3,993	16

The Grizzly Creek Complex is within this WAA on PALCO lands. The Grizzly Creek Complex is required to be protected from timber harvest and other management activities for the first 5 years of the permit. The fate of the Grizzly Creek Complex will not be determined by issuance of the ITP. The SYP/HCP and IA include a process by which the Grizzly Creek Complex, or that portion of the Grizzly Creek Complex that has not been acquired by the state or other entities at the end of the 5 years will be re-evaluated under section 7 of the Act and under CESA. This evaluation will consider the potential impacts to the marbled murrelet of harvesting the Grizzly Creek Complex, and will require protection of the complex as an MMCA for the life of the permit, if necessary, to avoid jeopardy to the murrelet. For the purposes of analyzing impacts on other covered LSH associated species, this analysis assumes that the Grizzly Creek Complex will be harvested during the life of the permit.

In addition to PALCO lands, Grizzly Creek State Park is within the action area in the Van Duzen River WAA. This park is expected to provide LSH throughout the plan period. Grizzly Creek State Park is approximately 268 acres in size, most of which is considered to be LSH.

Eel River WAA: The Eel River WAA totals approximately 427,468 acres, of which PALCO currently owns 73,862 acres (17 percent). At the end of the permit period, only miscellaneous patches will provide a limited amount of LSH in blocks greater than 80 acres in size on PALCO lands. There are currently 30,384 acres of LSH within this WAA. Approximately 12,885 acres of LSH will persist at the end of the permit period, of which, 6,224 (48 percent) will be in blocks at least 80 acres in size. Table 40 provides future projections of LSH on PALCO lands based on LTSY modeling information.

Table 40. Projected number of patches of LSH and acres of LSH by patch size on PALCO lands in the Eel River WAA by decade, based on LTSY model information.

Decade	Patch size								Total acres	Percent of PALCO lands in WAA
	0 - 80		80 - 475		475 - 1,000		>1,000			
	acres	no. of patches	acres	no. of patches	acres	no. of patches	acres	no. of patches		
Present	3,078	236	4,387	26	5,220	7	17,712	8	30,397	41
1	4,201	714	5,081	27	2,859	6	5,295	2	17,436	24
2	5,268	1,165	5,288	28	1,086	2	0	0	11,642	16
3	4,780	1,256	4,791	28	1,270	2	0	0	10,841	15
4	5,571	1,336	5,401	31	1,023	2	0	0	11,995	16
5	6,767	1,671	5,682	30	542	1	0	0	12,991	18

In addition to PALCO lands, HRSP is within the action areas in the Eel River WAA. This park is expected to contribute substantial amounts of LSH throughout the permit period. The park is approximately 51,800 acres in size, of which 21,534 acres are LSH.

Bear/Mattole WAA: The Bear/Mattole WAA totals approximately 159,054 acres, of which PALCO currently owns 30,580 acres (19 percent). At the end of the permit period, only miscellaneous patches will provide a limited amount of LSH blocks greater than 80 acres in size on PALCO lands. There are currently 7,382 acres of LSH within this WAA. Approximately 8,413 acres of LSH will persist at the end of the permit period, of which, 2,578 (30 percent) will be in blocks at least 80 acres in size. Table 41 provides future projections of LSH on PALCO lands based on LTSY modeling information.

Table 41. Projected number of patches of LSH and acres of LSH by patch size on PALCO lands in the Bear/Mattole WAA by decade, based on LTSY model information.

Decade	Patch size								Total acres	Percent of PALCO lands in WAA
	0 - 80		80 - 475		475 - 1,000		>1,000			
	acres	no. of patches	acres	no. of patches	acres	no. of patches	acres	no. of patches		
Present	2,829	161	2,741	17	0	0	1,815	1	7,385	24
1	2,823	384	1,165	8	663	1	0	0	4,651	15
2	2,759	562	832	6	0	0	0	0	3,591	12
3	2,596	422	1,188	9	665	1	0	0	4,449	15
4	2,282	452	1,219	9	0	0	0	0	3,501	11
5	5,835	1,108	2,578	18	0	0	0	0	8,413	28

Removal of special habitat components
Timber harvest may reduce the quantity and quality of special habitat components such as large green trees, snags, hardwood trees, and down logs. These components are used either directly by LSH associated species or by their prey for breeding, feeding, or cover. This effect could be substantial due to a potential loss of suitable nesting and denning substrate and reductions in prey populations; however, the retention requirements for these components (see **Description of the proposed action**) would minimize the impact of timber harvest, and provide levels of special components adequate for the needs of covered species. The effect, in terms of numbers of trees, snags, or logs, was not quantified for the purpose of this consultation.

Prescribed fire is often used as a management tool to remove unwanted vegetation and logging slash after harvest. Prescribed fire can consume habitat structural elements such as snags and downed logs that are important to LSH associated species. Monitoring for structural components described in the SYP/HCP will evaluate the effectiveness of management actions in retaining these habitat elements after prescribed burning. Additional measures are expected to be taken if necessary to ensure retention of these elements through subsequent harvest rotations.

Dispersal habitat condition
RMZs are expected to provide dispersal corridors throughout the permit period for certain late-seral associated species (Pacific fisher and California red tree vole). Prescribed fire is often used as a management tool to remove unwanted vegetation and logging slash after harvest, and can threaten the integrity of the LSH within the RMZs. The aquatic conservation plan proposes additional measures associated with RMZs to maintain adequate buffers between upslope burning activities and the stream channels. The measures are designed to keep prescribed fires out of

RMZs by limiting prescribed burns to only those times when optimal conditions exist and by requiring fire-setting techniques that will encourage the fire to burn away from RMZs. Numerous variables such as vegetative moisture content, wind, and humidity can influence the ability to control a prescribed fire once it is set. Although management of controlled burns may never be 100 percent effective, these measures described in the aquatic conservation plan are expected to minimize the possibility of fire from prescribed burning compromising the integrity of the shade-providing canopy in the RMZs.

Indirect effects

Predation

The overall mix of seral stages within PALCO lands will shift to a predominance of younger-aged stands throughout the permit period. This shift has the potential to negatively affect species associated with LSH in the following ways:

1. Increased fragmentation of LSH has the potential to increase the time late-seral associated species spend traveling and foraging away from protective cover, thereby exposing them to greater risk of predation.

2. The foraging efficiency of certain predators which prey on late-seral associated species may increase as a result in WAA-wide changes in vegetation seral stage composition.

3. Certain predators which prey on late-seral associated species may increase in density as a result of WAA-wide changes in vegetation seral stage composition. The resultant increased predation is likely to result in an increase in the loss of individuals from the population.

All three of the factors listed above are likely to adversely affect reproduction. The magnitude of this effect could not be quantified for this consultation.

Injury or disturbance

Indirect effects are similar to the direct effects listed above, but are likely to happen later in time. An example would be vehicle traffic expected to occur over the term of the permit on roads constructed early in the permit period. Vehicle traffic that occurs during the breeding season in or near late-seral habitat has the potential to disrupt essential foraging or breeding behaviors by: 1) causing abandonment of the breeding effort by failure to initiate courtship or nesting and denning, or complete incubation, 2) disrupting nesting/denning activity such as feeding young, and 3) causing premature fledging or dispersal of juveniles. A lack of breeding effort or breeding activity would negatively affect annual reproduction. Premature fledging or dispersal of juveniles may result in the increased likelihood of death or injury due to predation, lack of sheltering, or injury.

Habitat loss or modification
Timber management activities may result in the indirect loss or modification of LSH. Openings in forest stands created by several types of silvicultural prescriptions (e.g., clearcutting, selection harvest, shelterwood, seed tree, or commercial thinning) may increase the likelihood of all or portions of the stands being treated or the stands directly adjacent to treated areas being lost due to windthrow. Local topography affects the pattern and severity of windthrow. On PALCO lands wind-fallen trees are a common, but localized, occurrence. The exact magnitude of this effect could not be quantified for this analysis. However, the effects of such indirect habitat loss or modification on late-seral associated species would likely be minor.

Effects Common to Pacific Salmonids
The objective of this analysis is to determine if the direct, indirect, or cumulative effects of the proposed ITP for PALCO in Humboldt County, California, are likely to jeopardize the continued existence of threatened or endangered anadromous salmonids or destroy or adversely modify proposed critical habitat. Specifically, this analysis focuses on the direct, indirect, and cumulative effects of the proposed action on the threatened SONCC coho salmon; the SOCC chinook salmon, which has been proposed for federal listing as a threatened species; the northern California steelhead, which is a candidate for federal listing as a threatened species; and the SOCC coastal cutthroat trout, which is currently being reviewed for possible federal listing under the Act. The analysis also focuses on proposed critical habitat for both the SONCC coho salmon and the SOCC chinook salmon within the action area.

This analysis of effects is intended to determine if the actions covered by the proposed ITP and accompanying SYP/HCP could reasonably be expected to appreciably reduce the likelihood of both the survival and recovery of any of these species in the wild or appreciably diminish the value of critical habitat to listed salmonids. Because PALCO has applied for an ITP that would be effective for 50 years, this assessment considers the effects of actions that would occur between March 1, 1999, and March 1, 2049.

Assessment Approach
In recent years, the decline and extinction of Pacific salmon populations most commonly results from habitat loss and degradation in their spawning and rearing streams (Nehlsen et al. 1991). As a result this assessment of the effects of action associated with the proposed ITP for PALCO on four salmonids and proposed critical habitat is habitat-based. To conduct our assessment, we used the best scientific and commercial data available to estimate changes to water quality conditions, channel condition and dynamics, flow, hydrology, physical barriers to migration, and the general condition of watersheds that support the biological and ecological requirements of populations of these salmonids. An underlying assumption of this analytical approach is that these species will experience demographic changes (that is, changes in vital rates, population size, and distribution) commensurate with the changes in these habitat-related variables. As a result, these habitat-related variables are used as surrogates or indices of population trends for the purposes of this assessment. This approach is consistent with the approach used in the EIS.

The relationship between changes in habitat quantity, quality, and connectivity and the status and trends of fish and wildlife populations has been the subject of extensive scientific research and publication, and the assumptions underlying our assessment are consistent with this extensive scientific base of knowledge. For more extensive discussion of and data supporting the relationship between changes in habitat variables and the status and trends of fish and wildlife populations, readers should refer to the work of Fiedler and Jain (1992), Gentry (1986), Gilpin and Soule (1986), Nicholson (1954), Odum (1971, 1989), and Soule (1986, 1987). For detailed discussions of the relationship between habitat variables and the status and trends of salmon populations, readers should refer to the work of FEMAT (USDA Forest Service et al.1993), Gregory and Bisson (1997), Hicks et al. (1991), Murphy (1995), National Research Council (1996), Nehlsen et al. (1991), Spence et al. (1996), Thomas et al. (1993), The Wilderness Society (1993), and any of the numerous references contained in this rich body of literature.

The relationship between habitat and populations is embodied in the concept of carrying capacity. The concept of carrying capacity recognizes that a specific area of land or water can support a finite population of a particular species because food and other resources in that area are finite (Odum 1971). By extension, increasing the carrying capacity of an area (that is, increasing the quality or quantity of resources available to a population within that area) increases the number of individuals the area can sustain over time. By the same reasoning, decreasing the carrying capacity of an area (that is, decreasing the quality or quantity of resources available to a population) decreases the number of individuals the area can support over time. Restoring habitat that had been previously destroyed or degraded can increase the size of a population the habitat can support; conversely, habitat destruction and alteration can reduce the size of a population the habitat can support. In either case, there is a corresponding, but non-linear relationship between changes in the quality and quantity of resources available to a species in an area and the number of individuals that area can support.

The approach used in this assessment is intended to determine if the proposed action is likely to destroy or degrade the quantity and quality of natural resources necessary to support populations of the four salmonid species in the action area. Finally, the assessment approach is intended to determine if any changes are likely to decrease the size, number, dynamics, or distribution of listed salmonid populations in the action area in ways that appreciably reduce the likelihood of both the survival and recovery of listed species in the wild.

To make this determination, this assessment examines characteristics of watersheds and aquatic ecosystems within the action area that are essential to support populations of coho salmon, chinook salmon, steelhead, or coastal cutthroat trout. These variables, which are derived from a synthesis of most published reviews on the status and trends of Pacific salmon, must be present to ensure that watersheds function properly for listed salmon populations, include water quality, water quantity, channel conditions and dynamics, riparian vegetation, watershed conditions, physical barriers to fish migration within the watershed, and specific habitat variables such as food supply, substrate, large woody debris, pool frequency, pool quality, off-channel habitat, and remnant aquatic areas and refugia (USDA Forest Service et al. 1993, Gregory and Bisson 1997, Hicks et al. 1991, Murphy 1995, Nehlsen et al. 1991, Thomas et al. 1993). The variables are primarily developed from information on the habitat needs of salmon, including coho salmon, but will be treated as equally relevant to the other salmonid species considered in this Opinion. Although the presence of these variables does not assure the presence of salmon, salmon populations are not likely to survive in a stream if these variables are absent or highly degraded.

This assessment also analyzes whether the proposed action will adversely modify or destroy proposed critical habitat for the SONCC coho salmon and SOCC chinook salmon. It is necessary to analyze the effects of the action on the constituent elements of critical habitat proposed as essential to the survival and recovery of the listed species. If an action affects critical habitat, but does not appreciably diminish the value of constituent elements essential to the species' conservation, the adverse modification or destruction threshold is not exceeded. Many activities can be expected to take place within proposed critical habitat without appreciably diminishing the value of constituent elements essential to the species' conservation. On the other hand, the adverse modification threshold is exceeded when the proposed action will adversely affect the proposed critical habitat's constituent elements or their management in a manner likely to appreciably diminish or preclude the role of that habitat in both the survival and recovery of the species.

Constituent elements are not specifically defined in the proposed critical habitat designations for either coho (62 FR 62741, November 1997) or chinook salmon (63 FR 11482, March 1998). Therefore, in order to analyze whether the proposed actions will adversely modify or destroy proposed critical habitat, NMFS analyzed the effects of the action on the essential habitat features. That is, using the best scientific and commercial data available, we estimated the changes to substrate and sediment levels, water quality conditions, flow, stream temperatures, physical habitat elements, channel condition, chemicals and nutrients, riparian vegetation, habitat accessability, and the general condition of watersheds that support the biological and ecological requirements of coho and chinook salmon. In this, the analysis of effects of the action on proposed critical habitat was identical to the analysis of effect on the species.

To facilitate an understanding of the elements of the proposed action, a summary of the baseline environmental conditions is presented, followed by a summary of the proposed ITP, which includes a brief description of the covered activities and the proposed aquatic conservation plan. Following these summaries, the effects of the proposed covered activities are described, which is followed by an effects analysis of the aquatic conservation plan. Interrelated and interdependent effects are also discussed and cumulative effects are described last.

Background Summary of Baseline Conditions

As discussed previously, the action area for this biological opinion encompasses five watershed areas. These areas will be affected differently by the proposed action because of difference in the geology, topography, the types of timber management and road construction they will experience, and their significance to Pacific salmon. The following discussion provides a general overview of different features of these watershed areas as background summary for this analysis of effects of the proposed action.

The action area for this biological opinion encompasses approximately 815,063 acres of forest and associated grasslands in Humboldt County, California. It includes approximately 211,700 acres of lands owned by PALCO and a 1.3-mile buffer around those lands; these areas include the Mad River (Butler Valley hydrologic unit), Jacoby Creek, Freshwater Creek, Elk River, Salmon Creek, Humboldt Bay, Eel River, Van Duzen River, Yager Creek, Bear River, Salt River, and Mattole River watersheds.

Where data were available, the Baseline and following narrative discusses the known distribution of the four species of salmon within each watershed (data on the distribution and abundance of salmonids in the action area and within specific watersheds is derived from the Final EIS/EIR). However, it is important to note the limitations in the data on these species within these watersheds. The number and extent of surveys for these species in the action area is limited, so we cannot conclusively determine their actual distribution. Most importantly, a species may occur within these watersheds even though existing data do not show them as present. In the EIS and the Environmental Baseline section of this biological opinion, salmon were assumed present in a stream if suitable habitat existed; that protocol continues in this assessment of effects.

Bear/Mattole River Watershed. This watershed area includes the Bear River, Mattole River Delta, North Fork of the Mattole River, and Upper North Fork of the Mattole River hydrounits. This watershed area encompasses approximately 163,000 acres and includes approximately 30,495 acres of palustrine forested wetlands, 7,472 acres of riparian habitat, and 255 miles of streams (see Table 42 below). Twenty-five percent of the Bear River hydrounit and 9 percent of the Mattole River hydrounit are owned by PALCO.

Table 42: Stream Miles on PALCO Lands within the Bear/Mattole River Watershed Area (from EIS/EIR 1999).

Hydrologic Unit	Class I	Class II	Class III	Total
Bear River	22.6	58.8	45.6	127.0
Mattole Delta	5.0	10.2	9.9	25.1
North Fork Mattole River	5.0	17.7	15.0	37.7
Upper North Fork Mattole River	9.6	31.2	25.0	65.8
Totals	**42.2**	**117.9**	**95.5**	**255.6**

Based on the data presented in the Final EIS/EIR, chinook salmon and steelhead are recorded from the Bear/Mattole watershed area. Chinook salmon are known to occur within about 0.1 stream miles of the Upper North Fork Mattole hydrounit. Steelhead are known to be occur within about 9.0 stream miles of the Bear River hydrounit, 3.2 stream miles of the Mattole Delta hydrounit, 0.8 miles of the North Fork Mattole River hydrounit, and 6.3 miles of the Upper North Fork hydrounit. Existing surveys of this hydrounit have not conclusively determined the presence or absence of coho salmon and coastal cutthroat trout in streams. This WAA is outside of the known range of coastal cutthroat trout.

Functioning aquatic habitat in the Bear/Mattole WAA is limited by high embeddedness, excess fines, high water temperatures, low percent canopy cover, low percent pools, low levels of LWD instream and for recruitment, and low percent instream cover (PALCO 1998). The Mattole River is also listed under section 303(d) of the Clean Water Act for sediment and water temperatures problems.

Eel River Watershed. This watershed area includes the Eel Delta, Giants Avenue, Larabee Creek, Lower Eel River, and Sequoia hydrounits. About 0.3 miles of the Eel Delta are included in the Headwaters Reserve.

Table 43: Stream Miles on PALCO Lands within the Eel River Watershed Area (from EIS/EIR 1999).

Hydrologic Unit	Class I	Class II	Class III	Total
Eel Delta	12.6	39.7	27.4	78.7
Giants Avenue	1.2	4.9	4.3	10.4
Larabee Creek	21.5	62.7	43.9	128.1
Lower Eel River	30.9	130.8	91.5	253.2
Sequoia	13.7	42.1	30.8	86.6
Totals	**79.9**	**280.2**	**197.9**	**558.0**

Based on the data presented in the Final EIS/EIR, coho and chinook salmon, coastal cutthroat trout, and steelhead are recorded from the Eel River watershed area. Coho salmon are known to occur within 0.1 miles of the Eel Delta hydrounit, 3.9 miles of the Larabee Creek hydrounit, 2.9 miles of the Lower Eel River hydrounit, and 3.6 miles of the Sequoia hydrounit. Chinook salmon are known to occur within about 0.2 miles of the Eel Delta hydrounit, 0.2 miles of the Giants Avenue hydrounit, 6.0 miles of the Larabee Creek hydrounit, 6.7 miles of the Lower Eel River hydrounit, and 4.4 miles of the Sequoia hydrounit. Steelhead are known to occur within about 6.3 miles of the Eel Delta hydrounit, 0.7 miles of the Giants Avenue hydrounit, 12.3 miles of the Larabee Creek hydrounit, 15.6 miles of the Lower Eel River hydrounit, and 10.5 miles of the Sequoia hydrounit. Coastal cutthroat trout are known to occur within about 2.5 miles of the Eel Delta hydrounit.

Functioning aquatic habitat in the Eel WAA is limited by high water temperatures, low LWD abundance instream and for recruitment, low instream cover levels (PALCO 1998) and excessive sediment. The Eel River is also listed under Section 303(d) of the Clean Water Act for sediment and water temperature problems. Bear Creek, Jordan Creek and Stitz Creek have also been listed by CDF (1998) as being cumulatively affected by sediment problems due to land management activities.

Humboldt Bay Watershed. The Humboldt Bay watershed area includes the Elk River, Freshwater Creek, and Salmon Creek hydrounits. Approximately 66 percent of the Elk River hydrounit, 56 percent of the Freshwater Creek hydrounit, and less than 5 percent of the Salmon Creek hydrounit are owned by PALCO.

Table 44: Stream Miles on PALCO Lands within the Humboldt Bay Watershed Area (from EIS/EIR 1999).

Hydrologic Unit	Class I	Class II	Class III	Total
Elk River	21.5	49.2	49.4	120.1
Freshwater Creek	21.8	56.7	38.7	117.2
Jacoby Creek	0.0	1.6	0.9	2.5
Other	0.0	0.1	0.2	0.3
Salmon Creek	0.7	1.8	1.5	4.0
Totals	42.2	117.9	95.5	255.6

Based on the data presented in the Final EIS, coho salmon are known to occur within about 15.8 miles of the Elk River hydrounit, 11.1 miles of the Freshwater Creek hydrounit, 4.7 miles of the Salmon Creek hydrounit. Chinook salmon are known to occur within about 15.5 miles of the Elk River hydrounit, 9.9 miles of the Freshwater Creek hydrounit, 7.2 miles of the Salmon Creek hydrounit. Steelhead are known to occur within about 13.9 miles of the Elk River hydrounit, 11.2 miles of the Freshwater Creek hydrounit, 7.2 miles of the Salmon Creek hydrounit. Coastal cutthroat trout are known to occur within about 17.1 miles of the Elk River hydrounit, 7.3 miles of the Freshwater Creek hydrounit, 7.2 miles of the Salmon Creek hydrounit.

Under the proposed action, approximately 7,503 acres of land containing 3,117 acres of uncut, old-growth redwood forest would be placed in the Headwaters Forest Reserve. About 18.8 miles of the Elk River hydrounit within the Humboldt Bay watershed are within the Headwaters Reserve. Another 19.2 stream miles of the Elk River of the hydrounit currently owned by the Elk River Timber Company would be transferred to the Headwaters Reserve while another 44.3 stream miles of the Elk River would be transferred from the Elk River Timber Company to PALCO.

Functioning aquatic habitat in the Humboldt WAA is limited by shallow mean pool depths, low instream cover levels, and high levels of fine sediment (PALCO 1998). Freshwater Creek and Elk

River have been listed under section 303(d) of the Clean Water Act due to sediment problems. Freshwater Creek and Elk River have also been listed by CDF (1998) as being cumulatively affected by sediment due to management activities.

Mad River Watershed. The Mad River watershed area includes the Butler Valley and Iaqua Buttes hydrounits.

Table 45: Stream Miles on PALCO Lands within the Mad River Watershed Area (from EIS/EIR 1999).

Hydrologic Unit	Class I	Class II	Class III	Total
Butler Valley	0.6	6.1	3.9	10.6
Iaqua Buttes	2.9	9.5	5.7	18.1
Totals	3.5	15.6	9.6	28.7

The Mad River is listed under Section 303(d) of the Clean Water Act for sediment and turbidity problems.

Van Duzen River Watershed. The Van Duzen River watershed area includes the Van Duzen River hydrounit.

Table 46: Stream Miles on PALCO Lands within the Van Duzen River Watershed Area (from EIS/EIR 1999).

Hydrologic Unit	Class I	Class II	Class III	Total
Van Duzen River	30.4	83.3	65.7	179.4

Functioning aquatic habitat is limited in the Van Duzen WAA due to low percent pools, low abundance of LWD instream and for recruitment, low instream cover levels, and high levels of fine sediment (PALCO 1998). The Van Duzen River is also listed under Section 303(d) of the Clean Water Act for sediment problems.

Yager Creek Watershed. The Yager Creek watershed area includes the Lawrence Creek, Lower Yager River, Middle Yager River, and North Yager River hydrounits. This watershed area encompasses approximately 84,541 acres and has topography that ranges from 400 to 3,300 feet in elevation.

Table 47: Stream Miles on PALCO Lands within the Yager Creek Watershed Area (from EIS/EIR 1999).

Hydrologic Unit	Class I	Class II	Class III	Total
Lawrence Creek	25.6	55.9	41.7	123.2
Lower Yager River	19.6	51.6	46.7	117.9
Middle Yager River	7.2	6.2	6.3	19.7
North Yager River	3.5	9.2	7.5	20.2
Totals	55.9	122.9	102.2	281.0

Functioning aquatic habitat in the Yager WAA is limited by low percent canopy cover (PALCO 1998). The Yager River is also listed under section 303(d) of the Clean Water Act for sediment problems.

Summary of the Proposed Incidental Take Permit

The Action Area for this Opinion encompasses approximately 815,063 acres of forest and associated grasslands in Humboldt County, California. It includes approximately 211,700 acres of lands owned by PALCO and a 1.3-mile buffer around those lands; these areas include the Mad River (Butler Valley hydrologic unit), Jacoby Creek, Freshwater Creek, Elk River, Salmon Creek, Humboldt Bay, Eel River, Van Duzen River, Yager Creek, Bear River, Salt River, and Mattole River watersheds.

Covered Activities

The proposed ITP would cover timber management activities on approximately 203,000 acres of the action area (see table 48, below). These timber management activities include timber harvest and regeneration, site preparation (including burning), planting, vegetation management, thinning, and fire suppression. As part of the proposed action, approximately 174,386 of those 203,000 acres (86 percent), including lands transferred to PALCO from the Elk River Timber Company, would be managed intensively for timber production. Based on PALCO's timber harvest projections for the next 10 years, the largest proportion of the harvests would occur in the Lower Eel, Freshwater Creek, Elk River, Larabee Creek, and Van Duzen Creek hydrounits. These hydrounits would be most affected by timber harvests within this period.

Table 48. Approximate acres of timber harvest, by silvicultural prescription. Compiled from data in unnumbered table "Area Assigned by Silvicultural Prescription Code, Alternative 164g" in SYP/HCP, Volume III, Part C.

Plan Decade	Clearcut Acres	Active THPs [1]	Late-Seral Selection	Single Tree Selection	Restock	Total Acres Harvested
1	36,005	14,479	3,265	637	497	54,883
2	49,612	0	3,275	115	0	53,002
3	39,242	0	6,600	327	0	46,169
4	17,025	0	7,059	6	1,690	25,780
5	5,887	0	4,235	0	0	10,122
Totals	**147,771**	**14,479**	**24,434**	**1,085**	**2,187**	**189,956**

[1] Most existing THPs result in commercial thinning in decade 1, followed by clearcut in decades 2 or 3. For the purposes of this analysis, we assume that all active THPs will be implemented and these acres have been considered as harvested in the environmental baseline.

Proposed covered road activities include road maintenance, upgrading, construction, reconstruction, storm-proofing, closure, decommissioning and road use. Approximately 400 miles of new road would be built, adding to the existing 1500 miles, during the permit period: 150 miles in the first decade, 100 miles in the second decade, 75 miles in the third decade, 50 miles in the fourth decade, and 25 miles in the fifth decade. An unknown, unlimited number of roads will be reconstructed during the permit period. At least 750 miles of existing roads will be storm-proofed per decade with all the roads on the property have been brought up to that standard within the first 20 years. The road program also generally entails clearing vegetation from road rights-of-way, removing trees, grubbing (removing stumps and surface organics), grading, and compaction; extraction of rock, sand, and gravel from small borrow pits for use in road construction and maintenance, drainage facility repair, and erosion control; construction of stream crossings (bridges, fills with culverts, fords, and a variety of temporary crossings); maintenance of surfaced roads, seasonal roads, culverts, bridges, fords, cuts and fill slopes; and closure of roads, temporarily or permanently (i.e., closed or decommissioned).

The proposed ITP will also cover PALCO's operations of two commercial hard rock quarries in the action area. The two quarries are identified as Rock Quarry 1/Road 24 and Rock Quarry 2/Road 9. Rock Quarry 1 is located on a 3.5-acre site located in the Yager Creek drainage, which produces approximately 125,000 cubic yards of aggregate material. Rock Quarry 2 is located in the Lawrence Creek drainage of the Yager Creek watershed and is mined for commercial purposes. Approximately 450,000 cubic yards of material are available for production at Quarry 2. Operations at these two quarries would be covered under the proposed ITP for two years. After two years, any additional coverage for these quarry operations will require amendments to the ITP and associated conservation plan.

Quarry operations include excavations, drilling, blasting, screening, loading and hauling, road relocation, and erosion control. Extraction activities in borrow pits are similar to but less intensive than in quarries. Material is hauled off-site and transported by truck or rail to the areas they will be used to stabilize slopes, as bedding, and road base. Mining operations are seasonal, with most operations occurring from April through November.

PALCO uses many small sand or rock sources (borrow pits) in the action area for road maintenance, drainage facility repair, and erosion control. Activities associated with these borrow pits are part of PALCO's road and sediment control program and are covered by the ITPs for five years after the effective date of the permit. Coverage for borrow pits beyond that five-year period will require an amendment to the permits.

Aquatic Conservation Plan

As part of the proposed action, the SYP/HCP contains several strategies to conserve species covered by the ITP. The aquatic conservation plan defines the principle strategies that will be taken to minimize, mitigate and monitor effects of the proposed action on the four salmonid species being considered in this biological opinion. The aquatic conservation plan establishes interim prescriptions and requires that prescriptions be generated by watershed analysis. Interim prescriptions will be implemented as part of the proposed action unless they are modified by the results of a watershed analysis. Watershed analysis would be required for all of the lands covered by the ITP, with initial watershed analyses completed within the first 5 years of permit issuance.

The proposed aquatic conservation plan consists of six main interrelated elements to minimize, mitigate and monitor the effects of timber harvesting activities on aquatic ecosystems: riparian management strategy, hillslope management, road management, watershed analysis, a disturbance index, and monitoring. The aquatic conservation plan also includes measures for other covered activities: burning, rock quarries, borrow pits, and water drafting. Monitoring would be conducted to determine compliance, effectiveness, and trends for all covered activities. The effectiveness of the aquatic conservation plan requires full implementation of all six elements; if any of these elements are not fully implemented, the strategy may appreciably reduce the likelihood of the survival and recovery of the threatened and endangered aquatic species in the action area and may adversely modify or destroy proposed critical habitat. Through watershed analysis, new scientific studies, and monitoring, the prescriptions for any covered activity could be modified such that the SYP/HCP continues to meet the objective of maintaining or achieving, over time, a properly functioning aquatic habitat condition. Thus, the level of protection, after watershed analysis or other adaptive management, would be equal to or greater than the interim prescriptions. Mitigation for changed circumstances per the "no surprises" policy would also be implemented with the same objective to maintain or achieve, over time, a properly functioning aquatic habitat condition.

Headwaters Reserve
As part of the proposed action, the Federal government and State would complete acquisition of a portion of PALCO's property to establish a reserve (the Headwaters Reserve) upon issuance of ITPs. The acquired land would include 5,625 acres from PALCO and 9,468 acres from the neighboring Elk River Timber Company. The PALCO land and approximately 1,764 acres of Elk River Timber Company land would be placed into the Headwaters Reserve; the remaining Elk River Timber Company land would be transferred to PALCO. The Headwaters Reserve would be jointly owned by the Federal and State governments. The State would own the Owl Creek and Grizzly Creek acquisitions, if completed. Prior to the completion of the latter acquisitions, the Owl Creek area would be protected for the term of the ITPs, and the Grizzly Creek area would protected for 5 years. Management of the Headwaters Forest, following acquisition, is not part of the proposed action and will not be evaluated as part of this Biological/Conference Opinion.

Effects of the Proposed Incidental Take Permit
As summarized in the preceding section and discussed in more detail in the *Description of the Proposed Action*, the proposed action would allow timber management activities on approximately 203,000 acres of the action area. These timber management activities include timber harvest and regeneration, site preparation (including burning), planting, vegetation management, thinning, and fire suppression. Approximately 174,386 of these acres (86 percent) would be intensively managed for timber production. Based on PALCO's timber harvest projections for the next 10 years, the largest proportion of timber harvests would occur in the Lower Eel, Freshwater Creek, Elk River, Larabee Creek, and Van Duzen Creek hydrounits. The proposed action covers PALCO's entire road management program, including road assessments, road storm-proofing, road construction, reconstruction, and upgrading, road inspections, maintenance, use, closure, decommissioning, operation and construction of borrow pits and water drafting for dust abatement and fire suppression. In addition, the proposed action includes two quarry operations that involve excavation, drilling, blasting, screening, loading and hauling, road relocation, and erosion control activities. Material extracted from the quarries will be hauled off-site and transported by truck or rail beyond the action area.

In the following discussion, the general effects of the proposed timber and road management activities will be considered separately from the effects of the borrow pits and two quarries. After considering the direct and indirect effects of the proposed timber and road management activities, and the borrow pits and quarries, we will consider the direct and indirect effects of the conservation measures proposed in the SYP/HCP to minimize and mitigate the potential adverse effects of the covered activities on threatened and endangered salmon in the action area.

As proposed, approximately 11,290 acres of PALCO land would not be initially harvested, including 3,769 acres of RMZs and 7,521 acres included in MMCAs. Approximately 26,123 acres of land would be selectively-harvested in RMZs to protect riparian habitat within the action area. At least 10 percent of PALCO's lands in each WAA would be maintained as late seral forest, but approximately 69 percent of residual old growth would be harvested within the first 10 years of the ITP. At the end of 50 years, the area outside of RMZs and MMCAs on PALCO lands would be dominated by early- and mid-seral forests.

Since the 1950s numerous authors and groups have studied the effects of logging activities on salmon and their habitat. Comprehensive reviews of these studies have been conducted by Gibbons and Salo (1973), Salo and Cundy (1987), Meehan (1991), Thomas et al. (1993), FEMAT (USDA Forest Service et al.1993), Murphy (1995), and Spence et al. (1996). Most studies of the effects of timber harvests on salmon have focused on the relationship between specific habitat components and specific phases of salmon life cycles. Fewer studies have examined the collective effects of logging on the entire life cycle of salmon; as a result, our understanding of the relationship between habitat effects at the ecosystem level and the response of salmon populations is still being developed (Hicks et al. 1991). Although the information available on the effects of timber management on salmon and their habitats does not facilitate quantitative predictions of the effects of proposed timber management activities on the habitat of threatened and endangered salmon, those studies make it possible for us to project the probable direction and magnitude of habitat changes and their effects on salmon and their habitats.

Timber and Road Management

The broad category called "timber management" encompasses a large range of activities that includes the actual timber harvest, use of fertilizers, pesticides, fire retardants, and replanting activity. Road management encompasses the generalized categories of road existence, use, construction, maintenance, and closure.

Based on PALCO's timber harvest projections for the next 10 years, the largest proportion of the harvests would occurs in the Lower Eel, Freshwater Creek, Elk River, Larabee Creek, and Van Duzen Creek hydrounits. As a result, these hydrounits are most likely to experience adverse effects caused by timber harvests within this period. Within the first ten years of the proposed permit, PALCO expects to harvest timber on 5,543 acres of land within the Bear/Mattole River watershed; 26,234 acres within the Eel River watershed; 12,772 acres within the Humboldt Bay watershed; 186 acres within the Mad River watershed; 4,286 acres within the Van Duzen River watershed; and 5,883 acres within the Yager Creek watersheds.

PALCO proposes to construct 400 miles of new roads and a reconstruct an unspecified amount of roads. During the first decade, 150 miles of new roads are planned to be built. An unspecified and unlimited amount of roads may be reconstructed.

The following effect discussion address the different variables associated with properly functioning aquatic habitat.

Stream Temperature

Increased water temperatures in streams is often associated with the removal of shade-producing vegetation (Thomas et al. 1993). The principal source of energy for heating streams results from solar radiation directly striking the surface of water (Beschta et al. 1987). Water temperatures in forest streams increase as a result of reductions in canopy cover, which can increase stream temperatures by as much as 50° F (Beschta et al. 1987). Increases in stream temperatures up to 50° F were observed when clear-cutting was followed by burning (Brown and Krygier 1970 cited in Spence et al. 1996). The temperature increase in a stream is directly proportional to the area exposed to sunlight and inversely proportional to the volume of water in the stream. As a result, the effect of canopy removal on stream temperatures is greatest for small streams and diminishes as streams get wider.

Changes in stream temperature are considered harmful to salmon because these species are adapted to the specific, natural temperature ranges of their natal streams. Laboratory studies concluded that changes in stream temperature ranges can alter salmon development, growth, survival, and the timing of life history phenomena (Beschta et al. 1987). Based on the conclusions of these laboratory studies, increased temperatures beyond the preferred or optimal ranges of salmon are expected to cause juvenile salmon to leave their rearing areas or decrease their rates of growth. Berman and Quinn (1991) reported that fecundity and the variability of spring chinook salmon eggs were adversely affected by elevated water temperatures. High temperatures can inhibit the upstream migration of adult salmon and increase the incidence of disease throughout a salmon population. As stream temperatures increase, competition between salmon and warmwater fish species, which can cause salmon populations to become extirpated as a result of the competitive pressure (Reeves et al. 1987).

The percent canopy closure along streams within the action area is highly variable and ranges from 3 percent (Beer Bottle in the Bear/Mattole River watershed) to 96 or 97 percent (portions of Freshwater Creek in the Humboldt Bay watershed; Root Creek in the Van Duzen watershed; portion of the Lower Eel and Giants Avenue hydrounits in the Eel River watershed). Given the amount of acreage that would be subjected to timber harvests within the Eel River watershed within the first decade of the proposed action, and the significance of that watershed to one or more of the four salmonids being considered in this biological opinion, the greatest risk to these species caused by increases in stream temperatures associated with the loss or reduction of canopy closures are associated with the Eel River watershed.

Sediment

The soil in virgin forests generally resist surface erosion because their coarse texture and thick layer of organic material and moss prevent overland flow (Murphy 1995). All of the activities associated with proposed timber management on PALCO lands has previously been known to destroy the ability of forest soils to resist erosion and contributes to the production of non-point sources of stream pollution by fine sediment. Road construction, use, and maintenance; tree-felling, log hauling, slash disposal, site preparation for replanting, and soil compaction by logging equipment are all potential sources of fine sediment that could ultimately pollute streams in the action area (Hicks et al. 1991, Murphy 1995). The potential for delivering sediment to streams increases as hillslope gradients increase (Murphy 1995).

Timber harvests can substantially increase the delivery of sediment to streams through surface erosion and mass wasting events. The loss of protective vegetative cover can increase splash erosion (erosion caused by raindrops detaching soil particles) and reduce slope stability. Yarding activities that cause extensive soil disturbance and compaction can increase splash erosion and channelize overland flow. Site preparation and other actions which result in the loss of the protective humic layer can increase the potential for surface erosion (Hicks et al. 1991). Controlled fires can also consume downed wood that had been acting as sediment dams on hillslopes. After harvesting, root strength declines, often leading to slumps, landslides, and surface erosion (USDA Forest Service et al. 1993, Thomas et al. 1993). Riparian tree roots provide bank stability; streambank sloughing and erosion often increases if these trees are removed, leading to increases in sediment and loss of overhanging banks, which are important habitat for rearing Pacific salmonids (Murphy 1995). Increases in sediment delivery can destabilize channel morphology, outpacing the ability of the stream to transport sediment through the system.

Roads are considered the main cause of accelerated surface erosion in forests across the western United States (Harr and Nichols 1993). Processes initiated or affected by roads include landslides, road surface erosion, secondary surface erosion (landslide scars exposed to rainsplash), and gullying. In many locations, poorly-designed roads have been shown to have a larger effect on sedimentation than hillslope landslides or surface erosion (Kelsey 1980, Best et al. 1995, Wu and Swanston 1980, Swanson et al. 1987, Ziemer et al. 1996). Hagans and Weaver (1987) found that fluvial hillslope erosion associated with roads in the lower portions of the Redwood Creek watershed produced about as much sediment as landslide erosion between 1954 and 1980. In the Mattole River watershed, which is partially included in the action area, surveys found that roads, including logging haul roads and skid trails, were the source of 76 percent of all erosion problems mapped in the watershed (MRC 1987).

Road surface erosion is particularly affected by traffic, which increases sediment yields substantially (Reid and Dunne 1984). Other important factors that affect road surface erosion include condition of the road surface, timing of when the roads are used in relation to rainfall, road prism moisture content, location of the road relative to watercourses, methods used to construct the road, and steepness on which the road is located. In the proposed action area, the number of road and stream crossings is highest in the Lower Eel River hydrounit.

Historically, roads have adversely affected salmonid habitat by increasing sediment loads in streams, altering the morphology of stream channels, destabilizing streambanks, modifying drainage networks, creating barriers to movement, and increasing the potential for chemical pollution of the aquatic ecosystem (Furniss et al. 1991). Construction of road networks can also greatly accelerate erosion rates within a watershed (Beschta 1978, Best et al. 1995, Gardner 1979, Hagans and Weaver 1987, Haupt 1959, Kelsey et al. 1981, Reid and Dunne 1984, Swanson and Dyrness 1975, Swanston and Swanson 1976). Cederholm et al. (1981) reported that the percentage of fine sediments in spawning gravels increased above natural levels when more than 2.5 percent of a basin area was covered by roads.

Roads are also a chronic source of sediment to streams (Swanston 1991). Roads and related ditch networks are often connected to streams via surface flowpaths, providing a direct conduit for the sediment. Where roads and ditches are maintained by periodic "blading," the amount of sediment delivered continuously to streams may temporarily increase as bare soil is exposed and ditch-roughness features which store and route sediment are removed. In steeper terrain, road construction may trigger landslide processes that deliver large amounts of sediment directly into streams (Furniss et al. 1991). Improperly maintained roads may still fail, years after construction (Furniss et al. 1991). Roads built near watercourses can deliver sediment to streams, destabilize streambanks, and constrain the natural geomorphological migration of the stream channel. Road networks can affect hillside drainage; intercepting, diverting, and concentrating surface and subsurface flow, and increasing the drainage network of watersheds (Hauge et al. 1979, Wemple et al. 1996). This can lead to changes in peak and base flows in streams. Stream crossings can restrict channel geometry and prevent or interfere with migration of adult and juvenile salmonids (Furniss et al. 1991). Crossings can also be a source of sedimentation, especially if they fail or become plugged with debris, causing debris torrents and significant cumulative impacts downstream (Furniss et al. 1991, Murphy 1995).

Culverts and bridges associated with forest roads pose the greatest risk to streams that support salmon in the action area. When a culvert is plugged by debris or is overtopped by high flows, streams associated with these structures can be diverted, can contribute to road failure, and can cause severe sedimentation (Murphy 1995). Although proper design and location of these structures can minimize the risk of structural failure, any crossing structure is almost certain to fail if it is not maintained or removed when a road is abandoned (USDA Forest Service et al. 1993, Murphy 1995). Nevertheless, even proper culvert design and location is not proof against failure: for culverts designed for a 25-year flood, there is an 80 percent probability of failure over a 50-year period; for culverts designed for a 100-year flood, there is a 40 percent probability of failure over that same 50-year interval (USDA Forest Service et al. 1993). Given the 50-year duration of the proposed action, and the number of streams within the action area, the probability that one or more culverts associated with the 400-miles of road will fail is almost certain. The effects of such a failure on salmon habitat will depend on when it occurs, the stream the failure is associated with, antecedent weather conditions, the number of salmon using the stream system that is affected, and PALCO's response to the failure.

Mass wasting associated with roads can be more than 300 times more frequent than an undisturbed forest in comparable terrain (Furniss et al. 1991). Furthermore, because mass wasting associated with roads are relatively large, the amount of sediment pollution from roads greatly exceeds the amount from forests and clearcuts (Furniss et al. 1991).

As part of the proposed action, approximately 400 miles of road will be built during the permit period: 150 miles in the first decade, 100 miles in the second decade, 75 miles in the third decade, 50 miles in the fourth decade, and 25 miles in the fifth decade. At the end of the 50-year period of the proposed permit, there would be approximately 1,520 miles of road on PALCO lands. The

Eel River watershed would have the largest number of road miles, followed closely by the Humboldt Bay and Yager River watersheds.

The greatest potential risk of these roads to threatened and endangered salmon in the action area is in the Eel River watershed because it has the most stream miles of Class I and II streams (more than 360 streams). The Eel River watershed is scheduled to have the greatest number of new road miles within the first decade of the proposed action and the largest proportion of timber harvests. The Eel River watershed has the highest number of road crossings per mile of any stream in the action area (17.7 crossings per mile; Final EIS) which heightens our concern about the potential risk of sedimentation to salmon within this watershed. All four of the species being considered in this Opinion - coho and chinook salmon, coastal cutthroat trout, and steelhead are known to occur in the Eel River watershed - which heightens the likelihood that sedimentation associated with road construction, operation, and maintenance in this watershed will adversely affect threatened salmon within the watershed.

The Humboldt Bay watershed, which is scheduled to have the second greatest number of new road miles constructed in the first decade, has the second largest number of Class I and Class II streams within the action area. Coho and chinook salmon, steelhead and coastal cutthroat trout are known to occur within several hydrounits of this watershed, particularly the Elk River and Freshwater Creek hydrounits.

Table 49: Existing Road and stream crossings on PALCO lands by watershed (from table 3.6-3 of EIS/EIR).

	Watershed Areas					
Road Type	Bear/Mattole	Eel	Humboldt Bay	Van Duzen	Yager	Total
Stormproofing	31.11	16.83	10.15	0.0	26.29	84.38
Rock	5.78	151.54	99.66	48.91	146.29	452.18
Proposed for construction	11.75	58.27	51.32	11.44	17.29	150.07
Proposed for abandonment	0.0	0.0	0.58	0.0	0.0	0.58
Reconstructed	2.74	15.74	8.39	3.33	0.53	30.73
Other	96.02	328.67	146.14	113.73	117.65	802.21
Total Road Miles	147.40	571.05	315.24	177.41	308.05	1,520.15
Miles per square mile of PALCO lands	3.1	54.9	5.2	4.5	5.8	4.8

In addition to the relatively large amount of mass wasting associated with roads, lesser amounts of mass wasting is associated with clearcuts as roots of cut trees die and the soil they retain is lost.

Although the amount of soil erosion associated with these clearcuts is much smaller than that associated with roads, the greater area of clearcut makes this form of erosion a substantial source of sediment in salmon streams (Swanston 1991). The risk of this type of erosion increases 2 to 10 years after trees are cut (Burroughs and Thomas 1977, Ziemer and Swanston 1977); consequently, the proposed action poses substantial risk of increasing sedimentation within streams within the action area given the long-term duration of the proposed action and the spatial scale of the proposed timber harvests.

Past forest practices have changed the sediment equilibrium and storage in streams by increasing hillslope erosion and causing a loss of structural channel features (Everest et al. 1987). The loss of structure features of the stream reduces material storage and accelerates the routing of bedload sediment downstream. As a result, aggraded downstream reaches become wider, shallower, and more prone to lateral migration and bank erosion (MRC 1987, Sullivan et al. 1987).

As part of the proposed action, PALCO will operate two commercial hard rock quarries in the action area for two years in the Yager Creek watershed. The effects of rock mining on aquatic resources depend on the type of mining and distance from waters. Rock mining can cause increased sedimentation, accelerated erosion, increased streambank and streambed instability, and changes to substrate. Surface mining may result in soil compaction and loss of the vegetative cover and humic layer, increasing surface runoff. Mining may also cause the loss of riparian vegetation.

There are no data on the direct effects of sedimentation on salmon populations in the action area. However, a general picture of the effects of sedimentation on salmon populations can be constructed from investigations elsewhere in the Pacific Northwest. Fine sediment can directly reduce egg-to-fry survival, food production, summer rearing area, and winter survival; it can also change the morphology and stability of stream channels, causing long-term reductions in the carrying capacity of the stream and the survival of salmon in the stream (Murphy 1995). Holtby and Scrivener (1989) concluded that increased sedimentation following timber harvest reduced escapement by chum salmon (*0. keta*) by 25 percent in a stream in British Columbia. Scrivener (1991) concluded that sedimentation associated with logging over a 40-year period contributed to the decline of the chum salmon population on western Vancouver Island. Cederholm and Reid (1987; cited in Murphy 1995) concluded that sediment from a debris torrent and a streamside salvage operation caused a stream in Washington to aggrade to the point at which the stream dried up during the summer; the yield of coho salmon smolt in that stream declined by 60 to more than 80 percent.

Streamflow

Timber harvesting activities can have significant effects on hydrologic processes that determine streamflow. Timber harvests and road construction alter a watershed's water balance and accelerate surface flows from hillsides to stream channels (Chamberlin et al. 1991). These accelerated flows can change summer base (low) flows and peak flows during rainstorms and snowmelt. Harvesting and associated site preparation practices can alter total water yield, the timing and volume of peak runoff, and the volume of summer low flows. Removal of vegetation reduces evapotranspiration, which can increase the amount of water that infiltrates the soil and ultimately reaches the stream. Conversely, soil compaction caused by heavy equipment can decrease infiltration capabilities, increasing surface runoff. Forest management activities that substantially disturb the soil, such as yarding, burning, or road and skid trail construction, may alter both surface and subsurface pathways that transport water to streams (Murphy 1995, Thomas et al. 1993). This can increase or decrease total volume of streamflows. Logging can also alter the internal soil structure. As tree roots die, soil "macropores" collapse or are filled in with sediment. These subsurface pathways are important for water transmission. When they become blocked, water is forced to the surface, increasing surface runoff and accelerating erosion.

Peak flows increase after timber harvests because water is routed more quickly to stream channels once a forest has been cleared (McIntosh et al. 1994). During timber harvests, any activities that disturb and compact the soil increase surface run-off and allows surface run-off to reach streams faster than subsurface flows. Ditches associated with roads collect run-off and intercept subsurface flows and route them to streams more quickly. Roads acts as first order streams and channel more water directly into larger streams (Wemple 1994). Increased peak flow is detrimental to salmon because the resulting bedload overturn can scour stream channels, kill incubating eggs, and displace juvenile salmon from winter cover (McNeil 1964, Tschaplinski and Hartman 1983).

Large Woody Debris

Large woody debris is an integral part of streams in forested watersheds, providing structure to stream ecosystems and important habitat for salmon (Bisson et al. 1987). Large woody debris is a major habitat-forming structure in streams and can control stream morphology, regulating storage of sediment and particulate organic matter, and creating and maintaining fish habitat. Removal of large woody debris results in immediate loss of important habitat features and decline in salmon population sizes (Hicks et al. 1991). Debris removal generally reduces the quality and quantity of pools in a stream and destabilizes stream channels and cover that are essential to adult and juvenile salmon (House and Boehne 1987). The increases in riffles that accompany the loss of large woody debris may favor underyearling steelhead and cutthroat trout while harming coho salmon and older steelhead and cutthroat trout (Bisson and Sedell 1984, Murphy et al. 1986).

Logging activities can reduce large woody debris in several ways (Bisson et al. 1987). Tree-felling and yarding can destabilize existing large woody debris and later export that debris downstream or onto the floodplain or riparian zone. Salvage of merchantable logs from stream channels and floodplains removes large woody debris and destabilizes what is left. After logging, the amount of large woody debris in streams declines over time if riparian trees are cut because second-growth trees provide insufficient new debris to replace key pieces of debris as they decay or wash downstream (Andrus et al. 1988, Murphy and Koski 1989).

Woody debris in streams is naturally-depleted by decay, fragmentation, and transport to downstream stream reaches and floodplains (Bisson et al. 1987). The depletion rate depends mostly on the size of the debris, the species of wood, and the type of stream. Species like redwood and western red cedar (*Thuja plicata*) persist as wood debris for longer periods of time than other woody species found in the forests of the action area.

The effects of timber harvests in riparian areas can last hundreds of years because they eliminate new sources of large woody debris (Murphy 1995). If all sources of new, large woody debris are removed from riparian areas by clearcutting, the key pieces of LWD in a stream will disappear over a period of about 250 years (Murphy and Koski 1989). Because second growth forests do not contribute key pieces of large woody debris for 60 to 80 years after logging, clearcuts in riparian areas can cause large woody debris in adjacent streams to decline for 100 years after the cut with recovery requiring more than 250 years after a cut (Murphy 1995, Murphy and Koski 1989). Timber rotations of less than 100 years in riparian areas will permanently eliminate large woody debris from adjacent streams unless streams are protected by adequate buffer areas.

Habitat Access

Changes in stream channels afer timber harvests and road construction can interfere with salmon migration by blocking their passage through culverts, causing logjams, decreasing cover from predators, decreasing the frequency of large pools that are used for resting during migration, and adversely affecting water chemistry (temperatures and dissolved oxygen). Decreases in the number of pools in a stream caused by the loss of large woody debris can expose migrating adult salmon to predation and deprive them of resting habitat. Suitable pools are usually limited in number in any stream reach, making each of them important.

If they are not properly-installed, culverts can block the migrations of both outmigrating juvenile salmon and adults who are returning to spawn. If it is not properly installed, a single culvert can eliminate an entire salmon run by preventing adult salmon from reaching spawning areas.

Rock Quarries and Borrow Pits

The effects of quarrying on aquatic resources depend on the type of mining, the degree of disturbance, and the distance from waters. Various surface mines, including quarries, can cause increased erosion, increased streambank and streambed instability, and changes to substrate (Spence et al. 1996). Surface mining may result in soil compaction and loss of the vegetative cover and humic layer, leading to increased surface runoff. If quarries are located in riparian areas, loss of riparian vegetation will result. Surface mining can also affect water quality. Some chemicals used to clean or treat rock are toxic to aquatic species. Some types of rock, when exposed during mining, react to create acids. Run-off from mining areas may transport these acids to streams, leading to significant drops in pH levels (reviewed in Nelson et al. 1991). Acidification of surface waters by mining operations is generally considered to be the most serious consequence of mining (Spence et al. 1996). Borrow pits are constructed on a much smaller scale than rock quarries, but we expect that many of the erosion and sedimentation effects would be similar, especially for borrow pits located near streams.

Effects of the Proposed Conservation Measures

The proposed action includes an Aquatic Conservation Plan, which consists of six main interconnected elements to minimize, mitigate, and monitor the effects timber harvesting activities on aquatic ecosystems: the riparian management strategy, hillslope management, road management, watershed analysis, a disturbance index, and monitoring. The aquatic conservation plan also includes measures for other activities: burning, rock quarries, borrow pits, and water drafting. Monitoring would be conducted to determine compliance, effectiveness, and trends for all covered activities. The effectiveness of the aquatic conservation plan requires implementation of all six elements; if any of these elements are not fully implemented, the strategy may appreciably reduce the likelihood of the survival and recovery of the threatened and endangered aquatic species in the action area. NMFS assumes that PALCO will fully implement all the strategies. Through watershed analysis, new scientific studies, and monitoring, prescriptions for any covered activity could be modified such that the Plan continues to meet the objective of maintaining or achieving, over time, a properly functioning aquatic habitat condition. Mitigation for changed circumstances per the "no surprises" policy would also be implemented consistent with the goal to maintain or achieve, over time, a properly functioning aquatic habitat condition.

Measures Affecting Timber Management

The proposed action prescribes several strategies to minimize the impacts from harvesting on threatened and endangered species. To ensure that PALCO is managing its lands to promote sustained yields of timber, the proposed actions includes: (1) retention of at least five percent of its forested lands in each watershed analysis area in mid-seral vegetative stages; (2) a limit on increases in maximum harvest levels between the first and second decade by more than 15 percent, between the second and third decade by more than 12.5 percent, and by more than 10 percent thereafter; (3) management to ensure that harvests in any decade are less than long-term sustained yield volumes (2,335,200 mbf per decade).

Conservation measures proposed to minimize and mitigate the effects of timber harvesting activities on aquatic ecosystems include riparian management, hillslope management, road management, burning prescriptions, and a DI. The riparian, hillslope, and road strategies include prescriptions that all interlink to minimize and mitigate effects from specific elements of road management to protect the aquatic environment.

Riparian Management

The proposed aquatic conservation plan includes measures to minimize the impacts of timber harvesting on waters and riparian areas within the action area by establishing RMZs. Riparian buffer areas are a management tool designed to protect the canopy cover over streams, provide recruitments for large woody debris, add small organic matter to streams, stabilize streambanks, regulate nutrient and pollutant inputs to streams, and reduce potential adverse effects from sediment that is not captured through other management measures (Spence et al. 1996). Although riparian buffers alone are insufficient to ensure healthy aquatic habitat, they have been generally accepted as a way to minimize, mitigate, and, in some areas, avoid the adverse effects of timber management on aquatic communities (USDA Forest Service et al. 1993, Murphy 1995, Thomas et al. 1993, Spence et al. 1996, and others).

In summary, in Class I RMZs no harvesting is allowed immediately adjacent to streams (between 0 and 100 feet from the water), and the outer buffer has conifer retention standards designed to mimic attributes of a late-seral forest condition. Prescriptions for Class II RMZs are similar, except that the No Harvest Band is from 0 to 30 feet from the water. The total width of riparian forest with limited or no harvesting would actually be wider where there are channel migration zones, slopes greater than 50 percent, or mass wasting areas of concern. The total miles of stream where these additional prescriptions increase the overall buffer widths is unknown. Impacts would be further minimized by restricting harvest to one entry every 20 years, limiting the amount of basal area that can be removed in a single entry to 40 percent, requiring that trees left after harvesting conform to a specified tree size distribution, and the minimum pre- and post-harvest basal area standards. Loss of canopy caused by the presence of roads within the first 30 feet of a Class I or Class II RMZ would be mitigated by increasing the width of the No Harvest Band the equivalent width of the road prism on the opposite side of the stream.

Approximately 3,769 acres of RMZs would not be harvested under the proposed action. Approximately 26,123 acres of PALCO land would be harvested in a way that protects the function of the RMZs. Where harvest is allowed, the RMZs maintain the objective of developing or retaining a multi-layer tree canopy with large trees, down wood, and snags.

Temperature

One of the purposes of riparian buffers is to provide adequate overstory canopy to shade aquatic habitat. The removal of overhead canopy cover results in increased solar radiation reaching the stream, which result in increased water temperatures (Spence et al. 1996). Spence et al. (1996) reported that old-growth stands provided between 80 and 90 percent canopy cover from studies in western Oregon and Washington. Flossi et al. (1998) and CDFG (1996) recommend a 85 percent riparian canopy to properly shade streams that might be used by salmonids. A high canopy percentage within the action area is also necessary because current average summertime temperatures within the action area often exceed the 53.2 to 58.2°F range specified for juvenile coho salmon. On average, only riparian corridors in the Humboldt WAA, which includes portions of the Headwaters Forest, currently come close to this 80 to 90 percent canopy standard. According to the Final EIS/EIR, sampling locations on PALCO's ownership where temperature criteria for coho salmon were exceeded were located in reaches with less than 30 percent canopy cover, indicating that stream shading is an important factor influencing stream temperatures in the action area.

Based on review of numerous investigations, Johnson and Ryba (1992) concluded that buffers widths greater than 100 feet generally provide the same level of shading as that of an old-growth forest stand. Other authors (e.g., Beschta et al. 1987, Murphy 1995) have also concluded that buffers greater than 100 feet provide adequate shade to stream systems. The curves presented in FEMAT (USDA Forest Service et al. 1993) suggest that 100 percent effectiveness for shading is approached at a distance of approximately 0.75 tree heights from the stream channel. Assuming a tree height of 170 feet (100-year old redwood, site class 2; Lindquist and Palley 1963), this buffer width should be 127 feet wide to provide 100 percent shading effectiveness.

Based on calculations using various timber models (Peters 1998), in the aquatic conservation plan, the Outer Band (Class I) or Selected Harvest Band (Class II) would have an approximately 80 percent canopy cover immediately post-harvest. The Class I and II No Harvest Bands should also approach the 80 to 90 percent conifer canopy cover within the life of the ITP, if they are not currently already at this high canopy cover. Additional information to predict future canopy cover in RMZs can be found from the February, 1999 LTSY projections. These projections are that the total amount of late seral and old growth forests within Class I and II RMZs will increase over the life of the ITS from a current 12,600 acres to 18,267 acres in decade five. Based on the No Harvest Bands, the width of the total RMZs, and the harvest limitations in the outer portions of the RMZs, NMFS expects the Class I and II RMZs to provide 80 to 90 percent conifer canopy cover over time, thus providing the shade needed to maintain suitable water temperatures for Pacific salmonids.

Riparian buffers also function to minimize the impacts of upslope site preparation activities on streams temperatures. Burning is a common method used by PALCO to clear away debris from logging after a clear cut. Stream temperatures can be impacted by burning due to loss of overstory canopy and increases in sedimentation. Increases in stream temperatures up to 50°F were observed when clear-cutting was followed by burning (Brown and Krygier 1970).

The aquatic conservation plan proposes additional measures associated with RMZs to maintain adequate buffers between upslope burning activities and the stream channels. The measures are designed to keep prescribed fires out of RMZs by limiting prescribed burns to only those times when optimal conditions exist and by requiring fire-setting techniques that will encourage the fire to burn away from RMZs. Numerous variables such as vegetative moisture content, wind, and humidity can influence the ability to control a prescribed fire once it is set. The condition of the RMZs should also create a microclimate differential which may aide in limiting fire entry into a RMZ. Although management of controlled burns may never be 100 percent effective, these measures described in the aquatic conservation plan are expected to minimize the possibility of fire from prescribed burning compromising the integrity of the shade-providing canopy in the RMZs.

Sediment

Timber harvesting can substantially increase delivery of sediments to streams through surface erosion and mass wasting. Harvesting, especially with heavy equipment, removes the humic layer, increasing surface erosion. Yarding and heavy equipment use compacts soil, channelizing surface runoff (Spence et al. 1996). Root strength is lost as stumps decompose after logging, leading to slumps, landslides, and surface erosion (Everest et al. 1987). Removing trees from the banks of streams cause these banks to destabilize, increasing sediment delivery into streams.

Past natural and human-caused events have greatly impacted the sediment levels within watersheds in the action area. The current conditions of streams within the action area are described in detail in the Environmental Baseline section of this Opinion. In general, levels of fine sediment (<0.034 inches) and sand (<0.25 inches) are above levels considered to be functioning habitat. Several rivers within the action area have been listed under section 303(d) of the Clean Water Act as "water quality impaired" due to sediment problems. These rivers are the Mad River, Freshwater Creek, Elk River, Yager River, Van Duzen River, Eel River, and the Mattole River. The CDF has also listed Bear, Jordon, Stitz and Freshwater Creeks and Elk River as being cumulatively impaired due to sediment resulting from past forestry activities.

Riparian buffers can reduce the amount of sediment delivered from riparian and upland areas by providing physical barriers to trap sediments moving overland during rainfall events and by providing root stability to reduce the likelihood of mass failures along the stream channel (Spence et al. 1996). Various studies have suggested different buffer widths necessary to control overland sediment flow and minimize streambank mass wasting events. The FEMAT (USDA Forest Service et al. 1993) review of literature suggested riparian zones greater than one site-potential tree height from the edge of the floodplain as adequate to remove most sediment from overland flow. The review prepared by Johnson and Ryba (1992) noted that the available literature reported buffer widths ranging from 50 to 151 feet to control sediment, but that three of the five references they reviewed suggested 100 feet for this function. These buffer widths focused on minimizing overland flow, but O'Laughlin and Belt (1994 cited in Spence et al. 1996) suggested that sediment control from timber harvest activities cannot be achieved through riparian zones alone, because channel erosion and mass wasting are significant sources of sedimentation in forested streams. Therefore, additional buffers around areas susceptible to mass wasting would be necessary to provide full protection from upland and riparian sediment sources caused by timber harvesting.

Under the aquatic conservation plan, prescriptions within the RMZs are designed to minimize the delivery of sediment from riparian and upland sources. These measures include limiting the amount of ground disturbance within RMZs so that the physical barriers (e.g., humic layer, downed wood) that trap overland flow of sediment are retained; treating most sites within the RMZs that are disturbed due to harvest activity such that they will continue to trap overland sediment flow; prohibitions on removing downed wood that also provide physical barriers to overland flow; the No Harvest Band on Class I, II, and III waters to provide bank stability; and a high tree retention level in the Outer Band (Class I) and Selected Harvest Band (Class II) to provide slope stability. The width of RMZs, combined with the steep slope provisions on Class I and II waters, the sediment retention band (for Class II RMZs), and the mass wasting prescriptions for any mass wasting areas of concern within and upslope of RMZs were designed to minimize delivery of sediment from sources outside of the riparian buffer.

As noted above, the literature does not provide a single riparian buffer width that would buffer streams from unchannelized surface flow originating from upslope sources. The ability of riparian buffers to control sediment inputs is a factor of soil type, slope, and ground cover (Spence et al. 1996). The RMZs for Class I, II, and III waters established in the aquatic conservation plan are different widths, but all are within the range of buffer widths proposed in the literature.

Based on the buffer width recommendations from these literature sources, we expect that the Class I RMZs in the aquatic conservation plan will be of adequate width to trap suspended sediment, while the Class II RMZ width will be slightly less effective at sediment filtration. The effectiveness of the Class II RMZ at trapping sediment is improved by the additional sediment filtration bands on slopes less than 50 percent and the steep slope provision on slopes greater than 50 percent, thereby increasing the overall width of the sediment filtration buffer. The sediment filtration band requires retention of downed wood and other features that act as physical barriers to overland flow. The steep slope provision increases the total width of the Selected Harvest Band up to the break in slope or 400 feet. Because these provisions require the retention of natural features that act as physical barriers to overland flow, these additional measures are expected to provide some buffering from upslope sediment sources. With the additional buffer width provided by the sediment filtration band and steep slope provision, the riparian buffer width on Class II waters is within the range of widths recommended in the literature. In addition, the presence of mass wasting areas of concern activate the mass wasting strategy, increasing the degree of protection, but the amount and extent of this additional protection could not be determined for this biological opinion.

In Class III RMZs, the 30-foot No Harvest Band (or 10-foot No Harvest Band plus 20-foot minimum harvest in the 2,175 acres identified in the SYP) is smaller than the buffer widths recommended in the literature reviews, but the additional measures in the outer 30- or 70-foot bands are expected to provide some additional protection from overland sediment flow. As with the sediment filtration band on Class II RMZs, natural features that act as physical barriers to overland flow will be retained in the outer band of Class III RMZs, although no standing trees are expected to be left within the bands, post harvest. With these additional measures in the outer band of Class III RMZs, the total 50- or 100-foot width proposed in the aquatic conservation plan for Class III RMZs falls within the range of buffer widths recommended in the literature to control sediment, albeit at the lower end of the range. Therefore, the Class III RMZ prescriptions should be moderately effective at trapping all overland flow and have the potential to be highly effective at trapping overland flow from covered activities, although clearly not at the same level provided by the Class I or II RMZs. In addition, within Class III RMZs, the presence of mass wasting areas of concern may increase the degree of protection, but the amount and extent of this additional protection could not be determined for this biological opinion. We expect that a moderate amount of sediment from surface erosion will continue to be delivered into Pacific salmonid habitat from Class III waters due to past and current management. The impact from sediment inputs on aquatic resources will also be compounded by the high density of Class III waters within the action area.

Riparian buffers also function to minimize the impacts of upslope site preparation activities on streams containing salmonids. Burning is a common method used to clear away debris from logging after a clear cut. Prescribed burning destroys vegetative groundcover and the humic layer, creating large areas of bare soil and causing surface erosion and slope instability to increase (Spence et al. 1996). Even when burning does not expose bare soils, a water-repellent layer can form and reduce the ability to infiltrate into the soil, increasing the runoff available for surface erosion (Krammes and DeBano 1965, Bockheim et al. 1973 cited in Chamberlin et al. 1991). These negative effects from prescribed burning can be minimized or avoided by retaining adequate riparian buffers.

The aquatic conservation plan proposes additional measures associated with RMZs to maintain riparian buffer integrity. Our analysis of these measures was presented earlier in this biological opinion in terms of protecting riparian overstory canopy. We anticipate that these measures will minimize the possibility of prescribed burning compromising the integrity of the riparian zone. If the RMZs are not burned, we expect that they will function at various levels of effectiveness, commensurate with their width, to buffer waters within these zones from upslope sediment sources during site preparation burning activities. Class I and II RMZs are wider than Class III RMZs, and therefore are expected to provide more filtration capacity.

The probability of bank instability, landslides, and slumping due to loss of root strength would be minimized under the proposed management. No harvesting would be allowed within 100 feet of Class I waters, within 30 feet of Class II waters, or within 30 feet of Class III waters, except for the 2,175 acres where the No Harvest Band would be 10 feet. Within the outer bands of the Class I and II RMZs, the limited harvest prescriptions would assure a high number of trees in a wide range of sizes would be retained to provide root strength. These harvest prescriptions would also be extended upslope to the break in slope or 400 ft, whichever is less, for slopes steeper than 50 percent. In Class III streams, outside of the No Harvest Bands there are no standing tree retention standards, except those defined in the mass wasting strategy. The mass wasting strategy would provide additional protections against landslides or slumping caused by forestry practices within and outside of all RMZs. Under the mass wasting strategy, no harvesting would be allowed within areas identified as mass wasting areas of concern. These areas are defined to include areas identified as having extreme, very high, or high mass wasting hazard, inner gorges, headwall swales, and unstable areas, including those within Class I, II, and III RMZs. Combined with other measures to control mass wasting from other activities, we believe that these measures will minimize harvest-induced landsliding and slumping by retaining adequate root strength in the soil within and above RMZs. These prescriptions are not expected to be 100 percent effective, so some harvest-induced landsliding is expected to occur. Small to moderate amounts of sediment will continue to be transported into waters containing Pacific salmonids and proposed critical habitat depending on the condition of the individual RMZs.

According to the best scientific and commercial information, at least 95 percent of the vegetative cover within riparian buffers should be retained to properly filter overland sediment flow and minimize surface erosion from exposed soils. Although the exact amount of vegetative cover that will remain within the RMZs after harvest entry cannot be calculated, we expect that the prescriptions in the aquatic conservation plan will retain a high degree of vegetative cover and that most areas that are exposed would be treated such that the 95 percent vegetative cover recommendation will be achieved. This conclusion is based on the following: first, the equipment exclusion zones would minimize soil disturbance within RMZs. Second, most areas that are disturbed due to management activities would be treated. "Treatment" is not specifically defined in the aquatic conservation plan, but along the California north coast, it usually involves mulching and seeding bare soil areas such that surface erosion is minimized. Typical treatments include mulching with grass straw up to 2 inches depth over 90 percent of the exposed area. Areas left untreated would be less than 100 square feet each and would not be likely to deliver sediment to waters. We anticipate that these measures will combine to provide a high percentage of vegetative cover or other form of cover that will act as a physical barrier to overland flow and minimize surface erosion within riparian areas. With these prescriptions, sediment may continue to be delivered to Pacific salmonid habitat, but the amount from harvest-related surface erosion in RMZs should be minor.

With the combined measures discussed above, NMFS expects that moderate to substantial decreases in sediment delivery from timber management activities will occur within and above the Class I and II RMZs. The prescriptions identified for Class III RMZs, while not providing the same level of protection as Class I and II RMZs, would still result in minor to moderate decreases in sediment delivery over current levels. As proposed, the RMZs equal or exceed the published recommendations available in the literature. Consequently, based on the best scientific and commercial data available, we believe the proposed RMZs are likely to prevent an appreciable reduction in the value of stream habitat from sediment for the four salmonids proposed to be covered under the ITP, when used in concert with other conservation measures. This conclusion also applies to proposed critical habitat values.

Large Woody Debris
Timber management modifies the physical stream characteristics by removing LWD from streams and logging trees from adjacent riparian stands, decreasing the recruitment of LWD into waters (Bisson et al. 1987). Most wood likely enters the stream from toppling or windthrown trees from adjacent riparian stands (Spence et al. 1996), but wood is also provided to stream systems from hillslope processes such as debris torrents (McGarry 1994) and from the undercutting of streambanks and redistribution of wood from upstream sources. As a tool for forestry management, riparian buffers are designed to provide a supply of trees for potential recruitment into adjacent streams. Cederholm (1994) observed that in the available literature, the recommendations of buffer widths for maintaining recruitment of LWD to streams ranged from 100 to 197 feet. Based on a review of the available literature, FEMAT (USDA Forest Service et al. 1993) concluded that the greatest contribution of large wood to streams comes from trees within one tree height of the channel. Spence et al. (1996) also summarized the most recent studies, noting that buffers composed of late seral forest approaching one site-potential tree height are needed to maintain natural levels of LWD recruitment.

An additional consideration relative to providing LWD to streams from riparian zones is the potential size distribution of the large wood. Murphy (1995) notes that in streams, larger pieces of wood form key structural elements, serving to retain smaller debris that would otherwise be transported downstream. Studies by Bilby and Ward (1989) and Fox (1994) show that while the number of LWD pieces decreased with the increasing width of a stream, the average diameter, length, and volume of the LWD increased. Therefore, riparian buffers need to ensure not only an adequate supply of wood, but pieces of sufficient size to serve as "key pieces" (Murphy 1995).

There are limited data on current levels of LWD in streams within the action area. R2 (1997) summarized data collected by CDFG during stream habitat surveys. Values in those studies ranged from less than one piece of LWD per 100 feet of stream in the Eel River WAA to over 15 pieces per 100 feet in the South Fork of Freshwater Creek. Information is available in the Final EIS/EIR on the seral stage of RMZs by HU for Class I, II and III waters within PALCO lands (see Final EIS/EIR, figures 3.8-2a, 3.8-2b, and 3.8-2c). In general, most riparian stands within PALCO lands are currently in mid-to-late seral stages. There is very little old-growth or late-seral forest present on any PALCO lands within riparian areas except along the North Fork Mattole River and in the Headwaters Forest Preserve. Within PALCO lands, there are a total of 57,852 acres within Class I, II and III RMZs (using the highest estimated number of 3,200 miles of Class III waters). According to the 1999 LTSY calculations, of the 10,880 total acres in the 170 foot Class I RMZ (including the channel migration zone), there are currently 2,666 acres of late-seral forest, 456 acres of old-growth (including both Douglas-fir and redwood), and 1,429 acres of residual old-growth forest (including Douglas-fir and redwood). Thus, 42 percent of the current Class I RMZ has the potential to recruit LWD to the forest floor or stream. Based on the February 1999 LTSY projections, the 130 feet Class II RMZ, totaling 23,700 acres, includes 4,865 acres of late-seral forest, 789 acres of old-growth (including both Douglas-fir and redwood), and 2,395 acres of residual old-growth forest (including Douglas-fir and redwood). Thus, 34 percent of the current Class II RMZ has the potential to recruit LWD to the forest floor and stream. The remainder of the Class I and II RMZ stands are in earlier seral stages. No late-seral, old-growth or residual old-growth is accounted for in Class III RMZs. Over the 50 year life of the ITP, late-seral acres increase steadily, but acres of old-growth and residual old-growth drop steadily in the Class I and II RMZs, according to the February 1999 LTSY projections. By the fifth decade of the ITP, Class I RMZs are projected to contain 53 percent of forest types that have the potential to recruit LWD to the forest floor and streams, including 4,323 acres of late-seral forest, 327 acres of old-growth, and 1,166 acres of residual old-growth forest. Based on the 1999 LTSY projections, Class II RMZs are predicted to also contain 53 percent of forest types that have the potential to recruit LWD to the forest floor and streams, including 10,317 acres of late-seral forest, 333 acres of old-growth, and 1,801 acres of residual old-growth forest. For decade specific LTSY projections, refer to table 50.

Table 50. Projected acres of late-seral and old-growth timber types in RMZs (Source: LTSY projections, February 1999)

Anadromous Fish Analysis 1 [1/]

WLPZ_CODE	L	OD	OR	RD	RR	Grand Total
Present						
WLPZ_CODE [2/]	L	OD	OR	RD	RR	Grand Total
1,100.00	1,508.97	155.80	120.76	135.99	692.73	2,614.25
1,170.00	956.92	105.96	70.03	104.94	412.54	1,650.39
1,999.00	200.32	3.50	0.00	0.00	83.12	286.94
2,030.00	1,198.02	138.03	55.62	196.57	413.98	2,002.22
2,130.00	3,666.68	432.32	162.66	606.31	1,178.42	6,046.39
Grand Total	7,530.91	835.61	409.07	1,043.81	2,780.79	**12,600.19**
Decade 1						
WLPZ_CODE	L	OD	OR	RD	RR	Grand Total
1,100.00	1,508.52	136.51	115.08	120.11	622.07	2,502.29
1,170.00	917.35	93.57	62.08	87.87	348.22	1,509.09
1,999.00	208.00	3.50	0.00	0.00	82.16	293.66
2,030.00	1,221.19	129.00	54.70	175.14	378.55	1,958.58
2,130.00	3,748.11	407.25	127.14	532.08	1,029.81	5,844.39
Grand Total	7,603.17	769.83	359.00	915.20	2,460.81	**12,108.01**
Decade 2						
WLPZ_CODE	L	OD	OR	RD	RR	Grand Total
1,100.00	1,774.44	136.51	115.08	120.11	622.07	2,768.21
1,170.00	1,161.77	40.04	62.08	87.87	320.94	1,672.70
1,999.00	216.42	3.50	0.00	0.00	82.16	302.08
2,030.00	1,498.06	129.00	54.70	175.14	378.55	2,235.45
2,130.00	4,782.99	199.69	127.14	532.08	972.32	6,614.22
Grand Total	9,433.68	508.74	359.00	915.20	2,376.04	**13,592.66**
Decade 3						
WLPZ_CODE	L	OD	OR	RD	RR	Grand Total
1,100.00	1,831.90	136.51	115.08	120.11	622.07	2,825.67
1,170.00	1,191.97	27.81	62.08	87.87	270.79	1,640.52
1,999.00	217.44	3.50	0.00	0.00	82.16	303.10
2,030.00	1,557.29	129.00	54.70	175.14	378.55	2,294.68
2,130.00	4,953.29	183.81	127.14	532.08	800.76	6,597.08
Grand Total	9,751.89	480.63	359.00	915.20	2,154.33	**13,661.05**
Decade 4						
WLPZ_CODE	L	OD	OR	RD	RR	Grand Total
1,100.00	2,110.39	136.51	115.08	120.11	622.07	3,104.16
1,170.00	1,376.10	26.65	62.08	87.41	260.83	1,813.07
1,999.00	312.12	3.50	0.00	0.00	82.16	397.78
2,030.00	1,934.27	129.00	54.70	175.14	378.55	2,671.66
2,130.00	6,123.61	183.81	127.14	532.08	751.48	7,718.12
Grand Total	11,856.49	479.47	359.00	914.74	2,095.09	**15,704.79**
Decade 5						
WLPZ_CODE	L	OD	OR	RD	RR	Grand Total

1100	2,138.45	136.51	115.08	120.11	622.07	3,132.22
1170	1,863.38	10.01	62.08	85.77	256.05	2,277.29
1999	320.86	3.50	0.00	0.00	82.16	406.52
2030	2,061.16	129.00	54.70	175.14	378.55	2,798.55
2130	8,255.71	21.74	127.14	515.63	731.94	9,652.16
Grand Total	14,639.56	300.76	359.00	896.65	2,070.77	**18,266.74**

1/ This analysis summarizes the acres of late-seral, uncut old-growth Douglas-fir, uncut old-growth redwood, residual old- growth Douglas-fir,

and residual old-growth redwood in Class I and II RMZs and CMZs in the Project Area.

2/ 1100 = Class I RMZs within 100 feet of streams; 1170 = Class I RMZ between 100 and 170 feet from stream;1999 = channel migration zones;

2030 = Class II RMZs within 30 feet of stream; 2130 = Class II RMZs between 30 and 130 feet from stream.

Source: Foster Wheeler, 1999

For recruitment into streams and LWD, old-growth and residual trees provide larger, more complex wood pieces that function better in the stream system than smaller, less mature trees. Murphy (1995) notes that in streams, larger pieces of wood form key structural elements, serving to retain smaller debris that would otherwise be transported downstream.

We do not fully agree with the definition of seral stages used in the February 1999 projections discussed above and believe that the definition results in an overestimate of late-seral acres that have the potential to recruit large wood of adequate size. As defined for the LTSY modeling process, late-seral forest is made up of stands with overstory trees that average larger than 24 inches dbh, and are typically between 50 and 60 years old. Depending on the stream width, debris pieces that average 24 inches dbh are not large enough to function as "key pieces" within the stream system. The late-seral trees under this definition also have not had the time (50 to 60 years) to develop the structural components of mature or old-growth trees that provide structural complexity. Based on a review of literature summarizing the ability of riparian forests to fully provide habitat functions for salmonids, NMFS (1998) defines a late-seral stand as a multi-story stand between 80 and 120 years old. Using this definition of late-seral forest, the February, 1999 LTSY projections may not accurately depict the amount of late-seral habitat that will be available by the fifth decade. It is expected that the actual total amount of forest types with the potential to recruit LWD will be less than the predicted 53 percent for Class I and II RMZs, but the actual amount is unknown.

The aquatic conservation plan prohibits the salvage of downed wood from within Class I, II, or III waters or adjacent RMZs, except for defined emergencies. Although there is currently a deficiency of LWD within stream channels in the action area, this prescription is expected to protect the existing supply of LWD. Because the prescription applies to Class II and III RMZs as well as Class I RMZs, we expect that LWD currently present in these channels will be available for redistribution downstream into salmonid habitat during high flow events.

The best scientific information available indicates that, in order to provide a high number of recruitable trees of sufficient size to function as "key pieces" in waters, riparian zones within the action area should include approximately 24 redwood trees greater than 32 inches dbh, with approximately 18 of those redwood trees greater than 40 inches dbh per acre (Eyre 1980, Bingham, in litt. 1991, California Board of Forestry, in litt. 1992) to provide for adequate recruitment of LWD. We anticipate, based on the literature, that over half of recruitment of both 32 inch and 40 inch trees, and larger, into salmonid streams would come from the channel migration zone and the 100 foot Class I No Harvest Band. The February 1999 LTSY projections predict that the total amount of old-growth and residual old-growth forest within the Class I No Harvest Band remains relatively static during the life of the ITP, but that late-seral forest acres will increase (table 50). Recruitment potential from these areas will improve over the life of the ITP as the trees get older, provided the areas remain no-harvest zones. After watershed analysis, if entry into the channel migration zone and a portion of the Class I No Harvest Band (30 feet to 100 feet) is permitted, the aquatic conservation plan still requires that the 18 largest trees be retained in the RMZ after each harvest entry. Although the opportunity may exist for harvest entry, the goal of achieving properly functioning levels of instream LWD will determine the extent of harvest.

For the Class I Outer Band, management standards in the aquatic conservation plan would require retained trees to be distributed over several size classes. Under this distribution, 12 trees larger than 32 inches would be retained per acre. If the stated size classes are not present, larger tree size classes can be substituted, but smaller tree size classes can not be used for replacement. According to the February 1999 LTSY projections, the amount of late-seral forest within the Outer Band will increase from 957 acres to 1,863 acres in decade five, although old-growth and residual old-growth will decline from totals of 694 acres to 414 acres in decade 5. The restriction on harvest entries to once every 20 years will allow some older or more vulnerable trees within this band to be recruited into the stream or provide downed wood in the RMZ during the interim. The requirement to fell cable corridor trees towards waters, where possible, would also provide some short-term increases of LWD. The NMFS expects that Class I RMZ prescriptions, both pre- and post- watershed analysis, will provide for RMZs that will, over time, develop into stands with a high number of trees of sufficient size to recruit to the streams to function as "key pieces".

Class II RMZs will provide less LWD to salmonid streams, but an estimate of how much less is unknown. The Class II RMZ 30-foot no harvest buffer would provide some recruitment into the Class II waters. The LWD recruitment potential primarily comes from 802 current acres of old growth and residual old growth and 732 acres in decade 5. The outer 100-foot Selected Harvest Band would be managed with similar standards as the Outer Band in Class I RMZs, requiring that 12 trees larger than 32 inches be retained per acre. According to the February 1999 LTSY projections, the amount of late-seral forest within the Selected Harvest Band will increase from 3,667 acres to 8,256 acres in decade five, but the old-growth and residual old-growth will decline from 2,380 acres to 1,396 acres in decade five.

A minor amount of LWD would be expected to be recruited from the Class III No Harvest Band, with less coming from within the 2,175 acres identified in the SYP/HCP. The current acreage of trees of sufficient size to function as LWD are unknown, but is expected to be minimal based on previous harvest projections by PALCO. A more important role for Class III RMZs in the recruitment of LWD to fish-bearing streams may be from natural debris torrents triggered by severe storm events. Such mass wasting events are a part of a watershed's natural disturbance regime and can be beneficial to salmonids, providing coarse sediment and LWD into stream systems (Reeves et al. 1995). Because of the presence of the No-Harvest Band on Class III waters, we anticipate in the future, in the event of a landslide triggered in a Class III water, some larger trees will be delivered downstream. Combined with the recruitment potential from Class I and II RMZs, NMFS believes that the riparian management prescriptions, in the future, should provide for adequate levels of LWD for salmonid habitat, including proposed critical habitat. The effect of the RMZ prescriptions on LWD levels will not be immediate, therefore the lack of LWD instream will continue for some time, likely well beyond the life of the ITP.

Windthrow

PALCO's proposed management outside of RMZs and MMCA's includes clearcutting and other forestry techniques that, ecologically, have similar effects as clearcutting (e.g. shelterwood). Trees within riparian buffers that are immediately adjacent to clearcuts have a greater tendency to topple during windstorms than trees in undisturbed forests. Extensive blowdown of riparian stands can benefit Pacific salmonids and proposed critical habitat through the immediate increase in LWD. However, over the long-term, extensive blowdown of riparian stands results in the loss of the riparian functions vital to Pacific salmonids such as shading, bank stabilization, and the long term recruitment of LWD. Local site conditions dictate the vulnerability of stands to windthrow, but Rhodes et al. (1994) recommended that buffers need to be two site-potential tree heights wide in order to protect riparian buffers from windthrow.

The aquatic conservation plan does not directly address the issue of windthrow events except through changed circumstances and watershed analysis. The widest buffers are 170 feet, on Class I waters, and are approximately one tree height. Class II and III RMZs are smaller. The vulnerability of Class I and II RMZs to windthrow will be offset somewhat by the buffer widths in combination with steep slope provisions. On slopes greater than 50 percent, the aquatic conservation plan requires the outer band prescriptions to be extended to the break in slope or 400 feet from the stream. Where the steep slope provision applies, we anticipate that the resultant vegetated area will be wide enough to protect the core RMZ from the effects of windthrow. In these areas we expect the effects of a blowdown event on salmonid habitat will be minor. The total number of stream miles where the steep slope provision will increase habitat protections is currently unknown.

Class I and II RMZs that are on slopes less then 50 percent and which are not subject to the steep slope provision, will be more vulnerable to the effects of windthrow. Class III RMZs are highly vulnerable to extensive blowdown due to the small vegetated buffer width of 30 feet on either side of the channel. Prior to watershed analysis, there is no provision for identifying the vulnerability of stands to windthrow and protecting them accordingly. Through the watershed analysis process, the areas near streams that have shown past vulnerability to windthrow would be identified and appropriate prescriptions would be applied to protect the function of the RMZs.

Although we cannot currently predict how often windthrow events will occur, or how severe the blowdown will be in the event of a severe wind storm, we expect that the aquatic conservation plan will provide minimal to moderate protection to the integrity of the RMZ from windthrow events. Because such severe storms are uncommon events, NMFS anticipates that the effects from such blowdowns will be localized but the effects due to the loss of critical riparian functions along these reaches would be sustained for a long time.

Stream flow
Timber harvest and associated road construction can alter the hydrologic processes that determine stream flow. Generally, the removal of vegetation increases the amount of water that infiltrates the soil, and ultimately reaches the stream, by reducing water losses from evapotranspiration (Spence et al. 1996). In forested systems where fog drip contributes significantly to the total precipitation, such as the Humboldt Bay watershed, harvesting of trees may have little effect. Harr (1982 cited in Spence et al. 1996) found that in a study in the Cascade Range of Oregon, the total water yield decreased slightly after vegetation removal. Logging can change the total annual water yield, increase the magnitude of peak flows, alter the timing of peak flows, and increase or decrease the magnitude of summer low flows. Further information on the effects of logging on hydrologic processes can be found in Chamberlin et al. (1991) and Beschta et al. (1995).

Alterations to watershed hydrologic processes can be prevented by establishing a process for identifying and minimizing cumulative watershed effects. Although the probability of hydrologic changes resulting from timber harvesting and associated road building generally increases with the percentage of watershed that has been disturbed, there is no widely accepted threshold value for minimizing cumulative hydrologic effects. Within individual hydrological units, the aquatic conservation plan's DI threshold prescription is expected to limit the overall watershed disturbance from timber harvest and road construction. It is unknown whether the 20 percent DI threshold is an appropriate level for minimizing cumulative watershed hydrological effects, but it does provide some level of protection. Therefore, prior to watershed analysis, impacts to hydrologic processes are expected to continue from timber harvesting. The effect of these changes to Pacific salmonids and proposed critical habitat are varied depending on the type of hydrological changes that occur, but could include increased vulnerability of redds to scouring during high flow events and decreased summer rearing habitat. Watershed analysis, which must be completed within the first five years, would include an analysis of cumulative watershed effects. This analysis is expected to determine how a watershed responds to multiple management impacts. After watershed analysis, this site specific information would be used to tailor new prescriptions to minimize cumulative watershed effects and potentially modify the DI threshold. The DI threshold is discussed and analyzed further below.

Channel dynamics
The condition and dynamics of the stream channel in which Pacific salmonids live affects the suitability of the aquatic habitat. Timber management can alter the condition and dynamics of stream channels by removing riparian vegetation, which leads to a loss of root strength and ultimately, bank instability. Increases in sediment inputs from forestry activities destabilizes

channels, fills pools, and causes stream widening and shallowing. Adjacent floodplains provide off-channel habitat for juvenile and adult salmonids and dissipates the energy of water during high flow events. Timber harvesting, including salvaging LWD from channels and riparian areas, reduces the amount and complexity of off-channel habitats. Sedell and Froggatt (1994 cited in Chamberlin et al. 1991), observed that the loss of debris jams and related multiple floodplain channels vastly reduced channel and shoreline areas used by juvenile and adult salmonids.

Mitigation identified in aquatic conservation plan to protect channel condition includes the identification and protection of channel migration zones. Within identified CMZs, harvesting, including salvage operations, is not allowed. With this prescription, it is expected that timber harvesting will have a minimal impact on off-channel habitats. Other measures described above, including the No Harvest Band and erosion control measures within and above RMZs, are also expected to provide some protection to channel condition.

Riparian Management After Watershed Analysis

The prescriptions analyzed above will be applied to PALCO's ownership on an interim basis until watershed analysis can be completed for each watershed. Initial watershed analyses must be completed within five years of ITP issuance and then revisited every five years or sooner due to changed circumstances. Except for specified minimum and maximum No-Harvest Bands on Class I and II waters (30 feet and 170 feet, respectively) and the 18 largest tree retention standard within Class I RMZs, all prescriptions described and analyzed above may be altered due to watershed analysis. Although new prescriptions may be applied post-watershed analysis, the aquatic conservation plan requires that post-watershed analysis prescriptions must maintain or achieve, over time, properly functioning aquatic habitat conditions for salmonids. Therefore, NMFS expects that any post-watershed analysis prescriptions for riparian management, albeit potentially different from the interim prescriptions, will provide equal or greater protection for Pacific salmonids and will maintain or decrease the time required to achieve properly functioning aquatic habitat conditions on PALCOs ownership.

Hillslope Management

The proposed aquatic conservation plan includes measures to minimize the impacts of landslides caused by timber harvesting and road construction on streams and aquatic habitat within PALCO's ownership by implementing a mass wasting strategy. Types of mass wasting events in northern California identified by Bedrossian (1983) include translational/rotational slides, earthflows, debris slides, debris flows, inner gorge slides, and the debris slide slope/amphitheater. Deep seated slides such as earthflows and translational/rotational slides can be triggered by roads or streams cutting across the base of the slide, but the loss of root strength after timber harvesting probably does not affect deep-seated landslide movement. Both timber harvesting and road construction can trigger shallow rapid mass wasting events, such as inner gorge slides, debris slideslope/ amphitheaters, debris slides, and debris flows. These features are susceptible due to the loss of tree root strength after logging and when roads are constructed through them. Debris slides can also be triggered by road failures. The Final EIS/EIR extrapolated the extent of geomorphic features susceptible to mass wasting based on geology and slope. Based on this extrapolation, an estimated 60,388 acres of land within PALCO lands may be covered by the proposed mass wasting strategy. PALCO's July 1998 Draft HCP estimates that approximately 40,000 acres may be covered by the mass wasting strategy.

Under the proposed mass wasting strategy, we anticipate that there is a low risk of sediment delivery to waters from timber harvest due to the prohibition, and a low to moderate risk of sediment delivery to waters due to limited road construction from deep-seated landslides. Timber harvest activities are not likely to trigger movement within these features due to the prohibitions on timber harvesting on identified mass wasting areas of concern prior to watershed analysis. This assumes that the mapping process correctly identified the areas of concern. There is a higher risk that road construction and reconstruction will trigger movement within these features. This conclusion is based on the increased sensitivity of deep-seated landslide features to impacts caused by road construction and reconstruction and the potential for limited new road construction and reconstruction established in the mass wasting strategy across identified mass wasting areas of concern (i.e., road construction or reconstruction can proceed after approval by the wildlife agencies).

There is a slightly higher risk of sediment delivery from rapid mass wasting events triggered by road construction, but the risk from timber harvest due to the prohibition will be low. The geomorphic features where these rapid mass wasting events can be triggered are more common than deep-seated features within the action area. Under the proposed mass wasting strategy, timber management would be prohibited on mass wasting areas of concern prior to watershed analysis. The definition of this term specifically includes those features most likely to be the source of rapid mass wasting events such as inner gorges and headwall swales. There is a slightly higher risk that road construction and reconstruction will trigger rapid mass wasting from these features. This conclusion is based on the potential for new road construction and reconstruction across identified mass wasting areas of concern prior to watershed analysis. (i.e., road construction or reconstruction can proceed after approval by the wildlife agencies).

Although it is expected that the hillslope strategy will generally result in a low risk of sediment delivery to waters caused by covered activities on or across identified mass wasting areas of concern, there is a degree of uncertainty involved due to the mapping process. There is a possibility that geomorphic features prone to mass wasting may not be currently identified and properly protected from timber harvesting or road construction. According to PALCO (1998), the approach used to develop the mass wasting features map allowed for the delineation of steep terrain as well as unstable and extremely unstable lands at a broad scale. PALCO (1998) acknowledges that smaller features were probably missed by the process due to scale limitations. Ground-truthing and redefinition of area boundaries by the CDMG or a qualified professional geologist on a site-specific basis is permitted under the hillslope strategy, but this process will not necessarily identify new features that were not captured during the initial mapping process. We expect that the ground-truthing process will be effective at determining false-positives (i.e., mapped mass wasting areas of concern that do not exist on the ground), but the process is not likely to identify false-negatives (i.e., mass wasting areas of concern that are not mapped but exist on the ground) if they exist outside of mapped areas. PALCO (1998) identified approximately 38,000 acres that have yet to be characterized and mapped, these areas must be treated as mass wasting areas of concern until which time they are mapped. Watershed analysis requires a more thorough examination and mapping of mass wasting areas of concern. Through the watershed analysis process, we expect that these false-negatives and false-positives will be identified. Until watershed analysis is completed, the uncertainty will remain.

Hillslope Management After Watershed Analysis

The prescriptions analyzed above will be applied to PALCO's ownership on an interim basis until watershed analysis can be completed for each watershed. The prohibition on timber harvest and limited road construction/reconstruction described and analyzed above may be altered due to watershed analysis. Although we cannot predict what, if any, new prescriptions may be applied post-watershed analysis, the aquatic conservation plan does require that post-watershed analysis prescriptions must maintain or achieve, over time, properly functioning aquatic habitat conditions for salmonids. Also, as noted above, the watershed analysis process should result in improved mapping of mass wasting areas of concern, decreasing the possibility of false-negatives. Therefore, NMFS expects that any post-watershed analysis prescriptions for mass wasting areas of concern, albeit potentially different from the interim prescriptions, will provide equal or greater protection for Pacific salmonids and will maintain or decrease the time required to achieve properly functioning aquatic habitat conditions on PALCOs ownership.

Road Management

The proposed action prescribes several strategies to minimize the impacts from road construction, reconstruction, upgrading, maintenance, closure, decommissioning and use on threatened and endangered species. Road management activities can impact salmonid habitat by increasing the delivery of sediment to streams through surface erosion and mass wasting events, blocking or hindering migration of juvenile and adult salmonids, inhibiting recruitment of LWD from riparian stands, altering and constraining channel morphology, modifying the drainage network, and increasing the potential for chemical contamination (Furniss et al. 1991). Road management activities, particularly construction and maintenance activities that require heavy equipment in streams, can also directly impact Pacific salmonids by destroying redds, smothering or crushing eggs and alevins, increasing turbidity, blocking migration, and disturbing overwintering juvenile and adult salmonids. Water drafting for summertime dust abatement and fire suppression can entrain or impinge juvenile salmonids. Management prescriptions are proposed in the aquatic conservation plan to minimize the effects of these activities on listed salmon and their critical habitat in the action area.

The management measures for roads proposed in the aquatic conservation plan are divided into six categories: sediment assessment; road storm-proofing; road construction, reconstruction and upgrading; road maintenance; road inspections; and wet weather use.

Sediment assessment

This is a survey process and, in and of itself, has no direct or indirect effects on salmonids or proposed critical habitat. How quickly PALCO is required to complete the sediment assessment may indirectly affect salmonids in terms of the identification of high priority sites for storm-proofing or upgrading. A long assessment process could increase the probability of sediment delivery if the failure to identify high priority sites results in the generation of sediment into salmonid habitat or continued barriers to movement. Given the extensiveness of the existing road network, we believe the time limits established in the aquatic conservation plan are realistic and appropriate.

Storm-proofing
This process is designed to stabilize road features identified as having a moderate or high likelihood of delivering sediment to waters. Effects of storm-proofing on salmonids and proposed critical habitat include both short-term and long-term effects.

In the short-term, direct impacts to salmonids may occur during corrective work on water crossings. The use of equipment in streams during corrective activities on water crossings disturbs habitat, increases turbidity, and could crush eggs and alevins. Instream equipment use may degrade water quality through localized increases in suspended sediments. We expect that degraded water quality events caused by the use of equipment in streams will be short in duration and localized, but they could affect the ability of the fish to feed and block or delay the migration of juvenile or adult salmonids. Under the aquatic conservation plan, storm-proofing involving instream equipment will be conducted primarily between May 2 and October 14 of any year, thereby avoiding instream activity during winter or spring months when eggs and alevins may be present in the substrate. Some salmonid fry, particularly steelhead and coastal cutthroat trout, may not emerge from gravels until June. Storm-proofing after May 1 that involves instream equipment use could crush steelhead and coastal cutthroat trout eggs and alevins. Turbidity generated by instream equipment could settle on downstream redds, smothering or impairing the ability of fry to emerge from gravels. The majority of salmonids emerge prior to May 2, therefore we expect incidences of instream equipment crushing or smothering redds to be rare. During the summer months, the possibility of a juvenile or adult salmonid being crushed by instream equipment use is considered remote, due to their flight response. Juvenile wild salmonids tend to move to deeper water when disturbed (Knudsen 1992). This behavior may benefit the fish by moving them out of the way of possible harm from instream activities but could force them to relocate to inferior habitats.

Emergency work (e.g. unblocking culverts, stabilizing fill) may be completed during the winter and spring (October 15 thru May 1) if necessary in order to prevent water diversions and fill failure. Heavy equipment might be used in the stream for these emergency activities. If equipment is used in the water, there could be short term direct adverse impacts to Pacific salmonids and proposed critical habitat from these activities during the winter period, including destroyed redds, smothered or crushed eggs and alevins, increased turbidity, blocked migration, and a disruption or disturbance of overwintering juvenile and adult salmonids. Pacific salmonids are particularly vulnerable during the winter, when adult salmonids are migrating and spawning, and the spring, when eggs and fry are still present in the substrate. The activities could scare juveniles out of overwintering habitats such as side channels and deep pools, into inferior habitats or high velocity waters. We believe that impacts incurred due to emergency activities during the winter will be localized and short-term, but may be locally intense, especially if redds are destroyed. With the assessment and storm-proofing schedules established under the aquatic conservation plan, we expect that the frequency of occurrence for such extensive emergency stabilization treatments will be low. Also, over time, as roads and stream crossings are upgraded to the storm-proofing specifications required in the aquatic conservation plan, the necessity for winter and spring emergency stabilization work should decline. The short-term impacts would be further off set by the immediate and long-term benefits incurred from stabilizing fill, preventing culvert blow outs, and minimizing erosion problems.

According to Weaver and Hagans (1994), road-related activities should be performed during the dry season. The aquatic conservation plan prescriptions are expected to minimize sediment production during storm-proofing activities by limiting the timing of permitted activities, primarily to the dryer months (May 2 - October 14). As an additional minimization measure, during this time, storm-proofing would cease during periods of rainfall, and could not resume until soil was no wetter than is found during normal watering treatments. With these prescriptions in place, only minimal amounts of sediment inputs are expected to occur from storm-proofing activities not associated with water crossings during the dry season. Temporary and localized increases in turbidity could result from storm-proofing activities at stream crossings, which could affect the ability of fish to feed, and block or delay the migration of juvenile or adult salmonids.

In the long-term, we anticipate storm-proofing to reduce sediment generated from the existing road network. Storm-proofing actions include removing unstable fill, altering the road bed to reduce the potential for diversion of flows onto the road surface, installation of rolling dips and water bars to route overland flow, replacing inadequate and failing water crossings, and installing drainage structures. These actions are known to reduce the possibility of debris slides from road or water crossing failures and minimize the generation of sediment from surface erosion (Weaver and Hagans 1994).

The ability of PALCO to successfully minimize sediment delivery from their road network depends on the accurate and timely identification of unstable road features that may deliver sediment to waters and, once identified, the prompt stabilization of those features. The aquatic conservation plan requires that all roads will be storm-proofed within the first 20 years at a minimum rate of 750 miles per decade and 75 miles per year. Under this schedule, certain unstable road features will not be storm-proofed for 20 years, and impacts to salmonids or proposed critical habitat could occur during the interim if these features fail and deliver sediment into waters. The possibility of these unstable features failing before appropriate stabilization work is performed is minimized by the requirements to storm-proof the worst sites within 10 years, and the sites at risk of imminent failure within the first 3 years. Despite these actions, sediment generation cannot be completely eliminated and the road density per square mile of land will remain high, therefore NMFS anticipates a low to moderate amount of road-related sediment will continue to be delivered into salmonid waters and proposed critical habitat from road within the action area.

Road construction, reconstruction, and upgrades

Many of the impacts from road construction, reconstruction, and upgrades on salmonids and proposed critical habitat are similar to those described previously in this biological opinion for storm-proofing. Impacts include direct impacts from the use of equipment in streams and indirect impacts from the delivery of sediment through surface erosion or road-generated mass wasting events. Direct impacts from the use of equipment in streams will minimized during road construction and reconstruction because the winter period, during which these activities are prohibited, is longer than described for storm-proofing (October 15 through June 1). In addition to the effects described previously, additional impacts are expected due to the addition of 400 miles of new roads and an unspecified, unlimited number of miles of reconstructed roads to the road network during the life of the ITP.

New and reconstructed roads will be built to the storm-proofing specifications analyzed previously. We expect that the prescriptions on the amount of cut and fill, road width, road gradients, road surface drainage specifications, stream crossings design, and other construction, reconstruction, and upgrading standards will reduce the possibility of debris slides from road or water crossing failures and minimize the generation of sediment from surface erosion from new, reconstructed, and upgraded roads. Sediment from these sources can not be completely eliminated, and with an additional 400 miles of new roads, and an unspecified, and unlimited amount of reconstructed roads to be built during the next 50 years, we anticipate that a low to moderate amount of sediment will continue to be generated from these sources. This anticipated impact will be offset to an unknown extent by the requirement in the aquatic conservation plan that sediment generated from THP-related roads must be compensated for by sediment reduction through upgrading or road closure within a planning watershed. An unknown percentage of the proposed 400 miles of new roads and the reconstructed roads will be THP-related roads, therefore it is anticipated that sediment generated from these roads will be low.

The construction of new water crossings, while minimized, would not be capped or restricted in any quantitative manner under the aquatic conservation plan. Given that 400 miles of new roads and unspecified miles of reconstructed roads are to be constructed under the proposed action, the number of stream crossings is expected to increase across the Plan area. Culverted stream crossings are naturally susceptible to failure (Weaver and Hagans 1994), potentially generating large amounts of sediment directly into waters. Based on information provided in Weaver and Hagans (1994), the design specifications identified in the management plan are expected to increase the probability that culverted stream crossings can withstand a high flow event. In addition, we anticipate that the annual inspections and wet weather inspections with associated routine maintenance of these culverted stream crossings will aide in minimizing the potential for culvert blockages to cause catastrophic failures.

The building of new roads and the reconstruction of roads are not permitted in the RMZ. NMFS expects that this measure will also minimize the effects of roads on salmonid habitat by reducing the potential for additional road related sediment from reaching waters.

Road maintenance
Road maintenance operates in conjunction with road inspections, and is designed to prevent or minimize potential impacts from surface erosion or fill and culvert failures before they occur. The success of a road maintenance program depends, in part, on the successful identification of unstable areas in time to complete corrective work before the next wet season.

Road maintenance prescriptions include treating all permanent roads and water crossings within RMZs with rock, chip seal, or pavement, maintaining the proper surface drainage, and routine corrective work such as repairing cross drains, water bars, road surfaces, and unblocking culverts. These activities are expected to decrease surface runoff from roads, especially roads within RMZs, and minimize the possibility of catastrophic failures of culverts and unstable fill. The Aquatic Conservation Plan restricts non-routine maintenance activities to the summer months, between June 2 and October 14, of any year. This is expected to minimize the amount of sediment generated from such maintenance activities. Maintenance activities may require the use of equipment within waters. As described in the storm-proofing section, maintenance activities during summer months may degrade water quality through localized increases in suspended sediments. We expect that degraded water quality events caused by the use of equipment in streams will be short in duration and localized, but they could affect the ability of the fish to feed and block or delay the migration of juvenile or adult salmonids. Instream equipment use could also disturb juvenile and adult salmonids and force them to move away from preferred habitats. The impact from such disturbance is expected to be short in duration. Overall, we expect that the road maintenance program will decrease the amount of sediment entering streams and other waters from roads.

Road inspections
Inspections are a process and, in and of themselves, will not have any direct or indirect affects on salmonids or proposed critical habitat. In that the maintenance program, described and analyzed above, depends on the identification of maintenance needs through inspections, road inspections may affect salmonids and proposed critical habitat. If roads are not inspected on a regular basis, the probability of sediment delivery from a road or culvert failure increases.

Under the aquatic conservation plan, roads are required to be inspected annually to ensure that drainage facilities are in proper condition. Roads must also be inspected at least once during January or February, after a major storm event, and multiple inspections during the winter months are encouraged. Roads that cannot be inspected must be closed or decommissioned. Even closed and decommissioned roads must be inspected after the first five-year storm event to ensure that the treatments are functioning as intended. The combination of annual inspections and "storm-patrol" inspections in January and February, along with required schedules for correcting identified maintenance needs, is expected to reduce sediment production from roads and associated drainage structures. Because the current road network is extensive, the workload associated with the inspection program is anticipated to be heavy. Due to this, we anticipate that PALCO will begin decommissioning or closing roads unnecessary to PALCO's operations, further reducing sediment generated from the road network within the action area.

Wet weather road use
The aquatic conservation plan limits the use of the road network any time during the year when the road surface is not dry. When roads are wet, traffic impacts brings fine sediments to the surface of roads, in part by the "pumping" of fine-grained subgrade materials up through the surfacing gravels (L. Reid, in litt., 1998). Mud on the surface of the road is then washed of during the next storm event, increasing turbidity in salmonid habitat. Under the aquatic conservation plan, road use is limited with the most heavy road use prohibited during defined periods of precipitation, regardless of the time of year, and afterwards until the road is dry. The prescription focuses on preventing any visible increase in turbidity in a drainage facility or road surface which drain directly to a Class I, II, or III water. This prescription is expected to result in a significant reduction of incidences of turbidity in these waters generated from the pumping of fines.

Road use is allowed on wet roads for emergencies (both human safety and road related). Sediment will be generated by these events, but the occurrence of use is expected to be rare, and, in the case of road related emergencies, will be expected to decline over time as the road network is upgraded and storm-proofed. Limited light vehicle road use during periods of wet weather would be allowed on both rocked and non-rocked roads. Because of the specified vehicle weight (three-quarter ton trucks or less) limitation, in combination with the requirement to repair damage to the road surface or drainage facility within 24 hours, and the requirement that the damage should only be to an extent that repair can be made with hand tools, the impact of these vehicles is expected to result in low levels of sediment input into waters. NMFS also expects that any potential impact from light vehicle use on wet roads will be furthered minimized by limiting types of use on non-rocked roads prior to 48 hours after the termination of precipitation.

Other road related effects
Roads can also affect Pacific salmonids by blocking or hindering the migration of juvenile and adult salmonids, usually through the presence of stream crossings. Crossings can be barriers to migration, usually because of outfall barriers, excessive water velocity, insufficient water depth in culverts, turbulence disorienting fish, lack of resting pools below culverts, or a combination of these (Furniss et al. 1991). Under the aquatic conservation plan, stream crossings are to be minimized, but how this will be measured is not described. There are currently 3,728 water crossings on PALCO's ownership (Final EIS/EIR 1999). Given that the proposed action includes the construction of an additional 400 miles of new road on PALCO's ownership, the number of stream crossings is expected to increase across the Plan area, increasing the potential for barriers to migration. The aquatic conservation plan management prescriptions for stream crossing construction indicate that new and reconstructed roads across fish-bearing and restorable fish-bearing streams must provide for unimpeded fish passage. In the long-term, it is anticipated that

unimpeded fish passage will be achieved by following culvert installation standards currently in development by NMFS. While these standards are being developed, an unknown number of new and reconstructed water crossings may be installed on PALCO's ownership. New stream crossings must be permitted under California Fish and Game Code section 1603. Current culvert installation standards used by CDFG are believed to provide for unimpeded passage of adult salmonids, but whether they are as successful in providing for the movement of juveniles during low water conditions is currently unknown. Therefore, it is anticipated that some unknown portion of the culverts installed under the ITP will impede the passage of juveniles.

Water crossings on Class I waters are also to be sized to permit passage of a 100-year recurrence interval flood without overtopping the culvert. This culvert sizing should be large enough such that the bankfull width is not constrained and flow of water is not constricted, which could increase water velocity and cause streambed and streambank instability downstream. Therefore, we anticipate the effect of new stream crossings on channel morphology will be minimal. Current water crossings are sized to permit passage of a 50-year recurrence interval flood. Many of these existing culverts are probably constraining channel morphology. The effect of these culverts is expected to decline over time as these culverts are replaced under the storm-proofing program.

Drafting water from fish-bearing streams may also impact Pacific salmonids. Weaver and Hagans (1994) recommend dust control and watering to minimize the amount of dust and loose soil created by summer road use. PALCO usually drafts water for dust abatement purposes from local water sources, often directly from streams. Drafting that diverts a substantial portion of the flow can draw down water levels in pools, decreasing space availability and increasing the vulnerability of salmonids to predators. Water drafting in fish bearing streams can divert juvenile salmonids into the water tanks unless a screening device is placed over the intake hose. Screening devices can substantially reduce the direct impact of water withdrawals, but in order to provide for full protection, the appropriate size of the mesh or holes in the screen and the corresponding approach velocity to the screen must be designed properly (Smith and Carpenter 1987).

The aquatic conservation plan's drafting specifications require screening of hose intakes and limited diversion rates. According to the aquatic conservation plan, the diversion rate while drafting cannot exceed the rate of inflow. PALCO would be required to utilize the most recent NMFS water drafting screening specifications. The current NMFS standards were established based on laboratory tests (Smith and Carpenter 1987) to protect 100 percent of the smallest life stage and weakest swimming fish from entrapment and impingement due to screened diversions (R. Wantuck, NMFS, pers. comm., Jan. 1999). The specifications also require that screens must be kept in good repair and always used when drafting water. While in use, screens must be cleaned frequently to prevent the approach velocity from exceeding the standards established by NMFS. Impacts to juvenile Pacific salmonids from drafting are expected to be minimal.

The presence of roads within riparian zones can inhibit recruitment of LWD from riparian stands. Wood that falls across roads must be removed from the road to maintain accessability. In these situations, the road acts as an barrier, preventing recruitment of large wood from upslope sources into waters. Within Class I and II RMZs, mitigation for this impact increases the width of the No Harvest Band on the opposite side of the water an equivalent distance of that portion of the existing road prism. Although this will not fully compensate for the lost recruitment from the portion of the RMZ upslope from the road, some additional trees will be recruited from the expanded No Harvest Band. It is expected that the presence of roads within RMZs will continue to restrict the full recruitment of potential LWD into waters. Because of the current poor supply of LWD in waters within the action area, NMFS expects that, with the described mitigation, the effect of RMZ roads on the recruitment of LWD to be a moderate effect on the ability of a watershed to attain properly functioning levels of woody debris, within those watersheds with high densities of RMZ roads.

Bridges and other structures can be damaged or destroyed by the downstream movement of LWD during large storm events. Although the salvage of LWD is, generally, not permitted under the Aquatic Conservation Plan, exceptions are allowed where LWD is threatening life or property, including bridges and other road structures. Therefore, we anticipate that some pieces of LWD will be removed from waters due to such emergencies. Because of the current poor supply of LWD in waters within the action area, NMFS expects the effect of emergency removal of LWD to be a moderate to significant impact on the ability of a watershed to attain properly functioning levels of woody debris within those watersheds with high densities of roads and hence, a high density of water crossings.

Roads and stream crossings can alter and constrain channel morphology. The aquatic conservation plan prohibits new road construction within RMZs; this will prevent impacts from future road construction, but does not affect existing riparian roads. It is unknown how many riparian roads are currently constraining channel morphology. The impact from existing riparian roads on channel morphology is expected to continue across PALCO's ownership. Such impacts will persist as long as the road is present and, depending on how severely channel morphology is constrained, may alter stream conditions downstream.

Road networks can have significant impacts on hydrologic processes that determine streamflow (Spence et al. 1996). King and Tennyson (1984 cited in Spence et al. 1996) observed altered hydrology when roads constituted four percent or more of a catchment area. The Aquatic Conservation Strategy does not place density limitations on the number of miles of roads PALCO may construct during the life of the ITP. Within individual hydrological units, the DI threshold prescription is expected to limit new construction of roads, but the 20 percent threshold is higher than the percent roaded area observed to alter hydrology. Therefore, impacts to hydrologic processes are expected to continue from the road network, in the form of changes to the timing and volume of peak and base flows. The effect of these changes to Pacific salmonids and proposed critical habitat are varied depending on the type of hydrological changes that occur, but could include increased vulnerability of redds to scouring during high flow events and decreased summer rearing habitat.

When roads cross over waters, there is an increased risk of contamination from spills or petrochemicals dripping or washing off of equipment. There are currently 3,728 water crossings on PALCO's ownership. This number is expected to increase during the life of the ITP, therefore the possibility of chemical contamination is also expected to increase. Contamination of waters at amounts toxic to Pacific salmonids depends on both the likelihood of exposure and the toxicity of the chemicals (Norris et al. 1991). Contamination of waters from leaking vehicles is "somewhat of a concern" when equipment is used in streams (M. Yancheff, Caltrans, pers. comm., Jan.1999). Petroleum products are toxic to eggs and juvenile fish at certain concentrations (polycyclic aromatic hydrocarbons are toxic at concentrations between 500 and 1,000 ppb in estuarine sediments; J. Haas, USFWS, pers. comm Jan.1999), but small amounts of oil, gas, or diesel fuel dripping or washing off of vehicles or heavy equipment is normally not concentrated enough to affect salmonids (J. Haas, pers. comm, Jan. 1999). To prevent an accidental spill of any hazardous material, PALCO's spill contingency plan (Draft SYP/HCP, Vol. II, Part P) would be implemented. Based on discussions with contaminant specialists (J. Haas, USFWS), we expect the likelihood of a spill occurring to be low. If a spill were to occur at concentrations high enough to be toxic to fish, it is expected that the impact to Pacific salmonids and proposed critical habitat would be severe but localized and of short duration.

Disturbance Index
The aquatic conservation plan establishes an assessment of watershed disturbance at the hydrologic unit scale for purposes of minimizing cumulative sediment production, based on a measure of ground disturbance. This DI would be used to guide management in directions that will minimize cumulative sediment impacts. Although the DI is designed to assess sediment-related impacts, management actions taken to lower the DI below the set threshold of 20 percent could also minimize cumulative hydrologic impacts.

Data on watershed conditions indicate that many watersheds within the action area currently exhibit cumulative sediment impacts. The CDF has identified the following watersheds within the action area as cumulatively affected by sediment: Freshwater Creek, Elk River, and Bear Creek, Jordan Creek, and Stitz Creek (tributaries to the lower Eel River). Freshwater Creek and the Elk, Yager, Van Duzen, Eel, and Mattole Rivers have also been listed under section 303(d) of the Clean Water Act for sediment problems.

The DI is an evaluation process and, in and of itself, has no direct or indirect affect on Pacific salmonids or proposed critical habitat, but the establishment of an impact threshold beyond which management must be altered in order to decrease cumulative impacts below the threshold will have an effect. By limiting the total amount of impact from management activities that can occur in a watershed, we anticipate that this prescription will be moderately effective at limiting cumulative sediment impacts within these watersheds. This conclusion is based on the following factors: (1) The DI will be calculated at the hydrologic unit scale. Although this scale is not the smallest hydrological unit used in analyses, it should be adequately sensitive to discern localized but concentrated impacts. Management activities such as timber harvesting or road construction can not be concentrated in small sub-watersheds that may be locally important to salmonids. (2)

Roads that are used at any time during the 10-year interval and any improperly abandoned roads remain in the baseline calculation of DI. This means that the long-term sediment-generating potential from roads will be factored into any DI calculation. Given the current high density of roads in many watersheds on PALCO's ownership, a high number of sub-watersheds are believed to currently exceed the 20 percent threshold. This prescription will substantially minimize future management within these watersheds, until the DI calculation drops below the 20 percent threshold. (3) Prior to watershed analysis, the aquatic conservation plan places restrictions on management actions in any Class I sub-basin containing a salmonid population where the DI is calculated to be at or above 20 percent. Management restrictions include a ban on clearcutting, new road construction, skid trail construction, or broadcast burning within the identified sub-watershed. The management restrictions in these watersheds will substantially reduce sediment. production from future activities in these watersheds. Given the baseline conditions within the action area, we also expect that this prescription will be applied to a large, but currently unknown, portion of Class I sub-watersheds containing a salmonid population.

We have some concern with the DI threshold value of 20 percent. It is difficult to establish a set threshold for all areas because the response of watersheds to management activities depend on many geological and morphological variables unique to each area. Because of this uncertainty, we anticipate that cumulative effects may continue in certain sub-watersheds where the 20 percent threshold is too high. These cumulative sediment effects will impact Pacific salmonids and proposed critical habitat.

Disturbance Index After Watershed Analysis

Watershed analysis would include an analysis of cumulative watershed effects. This analysis is expected to determine how a watershed responds to multiple management impacts. After watershed analysis, this site specific information would be used to tailor new prescriptions to minimize cumulative watershed effects and potentially modify the DI threshold. Although we cannot predict what, if any, new prescriptions may be applied post-watershed analysis, the aquatic conservation plan does require that post-watershed analysis prescriptions must maintain or achieve over time properly functioning aquatic habitat conditions for salmonids. Therefore, NMFS expects that any post-watershed analysis DI thresholds or management prescriptions addressing cumulative effects, will provide equal or greater protection for Pacific salmonids compared to the interim DI and will maintain or reduce the time required to achieve properly functioning aquatic habitat conditions on PALCOs ownership.

Rock Quarries and Borrow Pits

The proposed action includes a few strategies to minimize the impacts from rock quarries and borrow pits on threatened and endangered species. Operations associated with the two rock quarries that will be carried out under the proposed action include excavations, drilling, blasting, screening, loading and hauling, road relocation, and erosion control. Sand and rock removed from small borrow pits are part of PALCO's road and sediment control program and are used for road maintenance, drainage facility repair, and erosion control.

Under the proposed action, operations at two quarries in the Yager WAA would be covered under the ITP for two years. Rock Quarry 1 is located on a 3.5 acre site in the Yager Creek drainage. Approximately 125,000 cubic yards of material are approved for removal from this quarry. PALCO is permitted to remove approximately 450,000 cubic yards of material from Rock Quarry 2. To minimize potential sediment and contaminant impacts, detention ponds and erosion control would continue to be used to reduce runoff to streams. Mitigation would be implemented so that operations would not result in a visible increase in turbidity in any drainage facility, work site, quarry area, etc., any of which drain to a Class I, II, or III water. Impacts from the operation of these two rock quarries may include increases in sediment and turbidity and acidification of waters from runoff. Due to the measures to control runoff, we anticipate that impacts from operations of these two quarries will be minimal.

Under the proposed action, an undisclosed number of small sand and rock borrow pits will be used by PALCO to provide material for road maintenance, drainage facility repair, and erosion control. Activities associated with these borrow pits would be covered under the ITP for five years. Measures to minimize impacts from borrow pits include all pertinent mitigation measures required for roads, including a prohibition on new borrow pits in RMZs, a prohibition on new borrow pits on mass wasting areas of concern prior to watershed analysis, the road construction/reconstruction standards, and wet weather operation restrictions. As part of watershed analysis, all borrow pits will be mapped and analyzed for site-specific and hydrologic unit scale impacts. Additional mitigation and minimization measures could be required as a result, including sediment control structures, limitations on overburden placement and distribution, removal of spoil material, revegetation, and abandonment.

The impact from these borrow pits on Pacific salmonids and proposed critical habitat is unknown. There is no information available to us that indicates the number, size, and location of these pits in relation to waters. We expect that the road management measures that will be applied to borrow pit operations will provide some level of protection to salmonids from borrow pit operations. Additional protective measures may be applied after watershed analysis. Due to the prohibitions on new borrow pits within RMZs and within mass wasting areas of concern (prior to watershed analysis), we expect that the total number of sites within these sensitive areas will decline, over time, with a corresponding decline in impacts to salmonids.

Adaptive Management
The aquatic conservation plan allows for changes to be made to management prescriptions in response to watershed analysis, new scientific studies, and monitoring. Although we cannot predict what, if any, new prescriptions may be applied based on this new information, the aquatic conservation plan requires that these prescriptions must maintain or achieve, over time, properly functioning aquatic habitat conditions for salmonids. Therefore, it is expected that any adaptive management prescriptions will provide equal or greater protection for Pacific salmonids and proposed critical habitat than the interim prescriptions described and analyzed above. We anticipate that, although adaptive management prescriptions may be different from the interim

prescriptions, these prescriptions, as a whole, will maintain or increase the trajectory of essential habitat features toward achieving properly functioning condition.

Monitoring

The aquatic conservation plan requires compliance, effectiveness, and trend monitoring to assure that over time, the prescriptions maintain or achieve properly functioning aquatic habitat conditions for salmonids. Monitoring will mostly take the form of passive observation, therefore direct impacts to salmonids and proposed critical habitat are expected to be minor. The application of monitoring findings may result in modifications in PALCO's management. As noted above, any changes to management prescriptions must maintain or achieve over time properly functioning aquatic habitat conditions for salmonids. Therefore, the impact from any changes to management prescriptions are expected to provide equal or greater protection for Pacific salmonids and proposed critical habitat than the interim prescriptions.

Changed Circumstances

Changed circumstances identified in the SYP/HCP include fire, windthrow, landslides, floods, and earthquakes. If any of these circumstances were to occur, an expedited watershed analysis would be completed on the hydrologic unit impacted by the changed circumstance. Site-specific prescriptions would be implemented upon the completion of the watershed analysis. The effect of post-watershed analysis prescriptions on Pacific salmonids and proposed critical habitat was discussed previously in this biological opinion.

Interrelated and Interdependent Effects

The use of forest chemicals (herbicides and fertilizers) during management activities is an interrelated action that may affect Pacific salmonids and proposed critical habitat. The application of these chemicals on PALCO's ownership would not be covered under the ITP. Both direct effects from exposure and indirect effects from the alteration of habitat or changes in primary and secondary production may occur within the action area.

Herbicides that currently can be used on PALCO's ownership include glyphosate (Roundup, Accord, and Rodeo), tryclopyr (Garlon), 2,4-D, atrazine (Aatrex), sulfometuron methyl (Oust), hexazinone (Velpar), and Imazapyr (Arsenal, Chopper). Adjuvants and diluents are often added to the above chemicals and may affect salmonids or proposed critical habitat separately from the herbicide.

The contamination of surface waters by herbicides, and the resultant risk of toxic effects on salmonids, depends on the form and application rate of the chemical, the application method, soil type, weather conditions during and after application, and the retention of riparian buffers. The persistence of these chemicals in the environment varies due to differences in water solubility, absorption rates into organic and inorganic matter, and sensitivity to photodecomposition or microbial activity. No-spray riparian buffers substantially reduce the risk of contamination (Norris et al. 1991), but toxic levels of chemicals may still reach streams from runoff and wind drift. If contamination of surface waters occurs, impacts to salmonids and proposed critical habitat include acute and chronic toxicity, leading to injury or death, behavior modifications, reduced growth, decreased reproductive success, and increased vulnerability to diseases and pathogens (reviewed in Beschta et al. 1995). Norris et al. (1991) reviews the behavior and toxicity of many of the commonly used herbicides, but this review is now nine years old and newer chemicals are not discussed. Although there is substantial literature on the toxicity of various herbicides on salmonids, most of the information comes from laboratory studies focusing on acute lethal doses and not on chronic toxicity (Spence et al. 1996).

Indirect impacts from the application of herbicides on PALCO's ownership include changes to the vegetative structure of riparian and upland stands, which may restrict the ability of the riparian vegetation to provide shade, organic debris, and other inputs into salmonid habitat. Salmonids may also be affected by the application of herbicides through changes in the primary and secondary production of the aquatic system. Herbicides that alter habitat for terrestrial and aquatic insect species may reduce the population of these species, affecting salmonids' food base. There is very little information in the literature about the effects of herbicides on aquatic invertebrates.

Fertilizers may also be used on PALCO's ownership to accelerate conifer growth. The application of fertilizers typically results in increased concentrations of nutrients, particularly nitrogen, in streams. High levels of nitrogens has the potential to promote nutrient enrichment of surface waters, leading to the growth in benthic algae and phytoplankton. High production of these organisms produces algal blooms, which can cause respiration problems, poor visibility, and deplete oxygen levels in water.

Due to the paucity of information concerning the chronic toxicity of forest chemicals and long term changes to salmonid habitat, we are unable to determine the effect chemical application will have on Pacific salmonids and proposed critical habitat. It is expected that impacts will occur from the application of chemicals within watersheds containing Pacific salmonids, but the impacts are unknown. The application of chemicals within these watersheds is subject to the requirements of all applicable Federal and State laws, including the requirements of section 9 of the Act.

In association with the SYP/HCP, PALCO is proposing to enter into a 5-year Streambed Alteration Agreement with CDFG pursuant to California Fish and Game Code section 1603 for certain covered activities that may substantially divert or obstruct the natural flow of or substantially change the bed, channel, or bank of any stream within the Plan area. Activities that would be covered under the 5-year Streambed Alteration Agreement include permanent road crossings over fish bearing or restorable fish bearing streams, permanent culvert road crossings on Class II and III waters, temporary crossings over fish bearing and restorable fish bearing streams, other temporary crossings, fords, water drafting, and road construction, reconstruction, and storm-proofing involving permanent and temporary crossings and fords. Covered activities that are not appropriately covered under the 5-year agreement would be addressed under separate agreements pursuant to Fish and Game Code section 1603.

Mitigation proposed under the 5-year Streambed Alteration Agreement avoids or minimizes many of the impacts of these covered activities on Pacific salmonids. Crossings on fish bearing or restorable fish bearing streams would not be installed before June 15 or after October 15, thereby restricting instream activities to the summer months, when salmonid eggs and alevins are not in the gravel. Temporary crossings must be installed after June 15 and removed before October 15. This also avoids impacts to salmonid eggs and alevins, and minimizes the possibility of blocking or hindering adult fish passage. Permanent crossings of fish bearing or restorable fish bearing streams must provide for fish passage, although the specific prescriptions are designed to provide for adult salmonid migration. There are no specific prescriptions for summertime movement of juveniles and adults, therefore some constraints to summertime movement are anticipated. Crossing designs that alter water velocity or significantly alter the channel profile are not permitted. Bare mineral soils exposed by any permitted operations must be treated. The prescription requires 100 percent of bare soil, except for within the streambed, to be treated immediately upon completion of work with a minimum of 4 inches of straw mulch and 100 pounds/acre equivalent barley seed. With this prescription, only minimal surface erosion is anticipated. Increases in turbidity are expected from any instream equipment use, but this turbidity should be localized and of short duration but they could affect the ability of fish to feed and block or delay movement of salmonids. Adults and juvenile salmonids may be disturbed and harassed by instream equipment use. Injury to these salmonids is not anticipated due to their flight reflex, but the disturbance may force them out of preferred habitats into inferior locations, where they would be more susceptible to predation and temperature-related stress. This effect is expected to localized and would last only as long as the equipment is in the water.

Impacts on salmonids could include temporary increases of turbidity, degraded or destroyed habitat, harassment of juvenile and adult salmonids, temporary or permanent blocking or hindering of salmonid movement, changes to water velocity and channel profile, and crushing or smothering of eggs and alevins. These effects are discussed in detail in the road management section of the Aquatic Effects section, above. The effects will be localized. The overall impact to the species in the action area will be minor.